

NASA Contractor Report 3485

A Compendium of Hypokinetic and Hypodynamic Animal Studies

Linda G. Pleasant and Phyllis T. Axelrod

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INTRODUCTION

One of the primary tasks of space biology is to clarify the physiological effects of weightlessness on animals. As a result of the American and Soviet space programs, man has learned that physiological changes occur when animals are exposed to space flight. These changes include cardiovascular deconditioning, bone demineralization, loss of muscle mass, and fluid and electrolyte alterations. When these physiological effects were observed during space flight, NASA became interested in duplicating the effects on Earth. One way to study these effects is through simulated weightlessness.

NASA has been funding zero gravity studies to investigate the mechanisms involved in the physiological changes resulting from exposure to weightlessness. It has been established that hypokinesia and hypodynamia serve as excellent models for a number of the effects arising during weightlessness; for this reason, scientists in space biology are interested in animal studies which investigate the effects of hypokinesia, hypodynamia, immobilization, restraint, denervation, etc. So much research has been published on this problem during the past two decades that a need arose for a single source of reference. This compendium will hopefully fulfill that need.

The objectives of this compendium are twofold, to not only summarize that research which has already been performed, but to provoke new research by exposing areas in which there is a deficiency of information. This report is intended as a research tool for investigators studying the effects of zero gravity.

The main section of this compendium is composed of summaries for each research paper cited. The scientific literature was searched for relevant publications for the years 1960 through 1978; earlier publications were identified from the bibliographies of the research papers summarized. Secondary sources searched for research papers include: Index Medicus; Biological Abstracts; International Aerospace Abstracts; Scientific and Technical Aerospace Reports; and the Library of Congress S&T Alert Abstracts. Review papers were not summarized but are listed for your reference in the appendix. The summaries of the research papers are arranged in alphabetical order by author, and within author by publication date. Brief descriptions of the methods and results are given for each paper. The stylized format used for presentation of cited papers was designed to convey the most information in quickly assimilable form without excessive simplification. Because of the differences in the detail and scope of the research reported in these papers, the summaries may sometimes seem to have an inconsistency in the amount of information reported. All essential information, when given, has been included in the summaries; where more details are needed the original paper should be consulted. A subject index is provided for access to the research papers by physiological system.

We would like to gratefully acknowledge the assistance of Joseph Rowe, Letty Limbach, Annie Lo, and April Roy in the preparation of this compendium.

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Summaries

AUTHOR(S): Abdusattarov, A.

EXPERIMENT TITLE: Effect of Hypokinesia on Invertase Activity of the
Mucosa of the Small Intestine

SUBJECTS: 84 Mongrel white male rats (170-180 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) hypokinetic in small cages for 30 days; 2) controls.
Invertase activity of intact and homogenized sections of the small intestine
was determined by photolorimetry. Diet: standard rations and water ad
libitum.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: From 2-8 days invertase activity dropped sharply (to 52-55%).
Beginning with day 12, the level of the intact sections went back to that
of the control. In the homogenized sections it increased by 43%. By
day 18, invertase activity was practically the same as controls and by
day 24-30, it increased sharply both in the intact and homogenized
preparations.

SOURCE: Uzbekskii Biologicheskii Zhurnal No.1: 61-62, 1978

AUTHOR(S): Abdusattarov, A.

EXPERIMENT TITLE: The Enzyme Spectrum of the Small Intestine with Hypodynamia Under Conditions of High Temperature

SUBJECTS: 24 Male Wistar rats

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Four groups: 1) kept in individual cages at high temperatures (35-36°C) with unlimited movement; 2) kept at room temperature in special cages that sharply limited movement; 3) kept in the same conditions at high temperatures (35-36°C); 4) controls. On the 20th day all animals were killed. Measurements in the mucous membrane of the small intestine: invertase, dipeptide hydrolase, and monoglyceride lipase activity by the photocalorimetric method.

IMMOBILIZATION METHOD: Cage

RESULTS: The heat factor caused invertase activity to decrease slightly and dipeptidase activity to increase. Under conditions of hypodynamia at normal temperatures, invertase activity remained the same and dipeptidase, monoglyceride lipase and alkaliphosphatase activities slightly increased. With hypodynamia at a high temperature, invertase activity fell sharply and monoglyceride lipase activity increased sharply.

SOURCE: Uzbekskii Biologicheskii Zhurnal No.4: 80-81, 1978

AUTHOR(S): Abidin, B.I., V.I. Belkin, L.T. Poddubnaya, and
G.D. Yukhnovskiy

EXPERIMENT TITLE: Effect of Restriction of Motor Activity of Animals
on Their Tolerance to an Acute Exposure to Carbon
Monoxide

SUBJECTS: 40 White male rats (165-180 gm)

AREA OF STUDY: Respiration

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats were placed in
cages for 3, 15 and 30 days. Upon termination of the experiment the
tolerance to an acute exposure of carbon monoxide was investigated.
Measurements: overall state; behavior; weight; intensity of oxygen con-
sumption.

IMMOBILIZATION METHOD: Cage (special cell-like)

RESULTS: Hypokinesia produced a dozing status with no weight gain.
Beginning on the 3rd day, hypokinesia caused some increase in oxygen
consumption (16.3%). Hypokinesia also reduced the rats' tolerance to
acute exposures of carbon monoxide.

SOURCE: Space Biology and Medicine 7(2): 133-135, 1973

AUTHOR(S): Abidin, B.I., V.I. Belkin, and V.V. Kustov

EXPERIMENT TITLE: Joint Effect of Hypokinesia and an Increased Oxygen
Content on the Tolerance of Animals to Carbon Monoxide

SUBJECTS: 80 White male rats (170-180 gm)

AREA OF STUDY: Respiration

OBJECTIVES: In title

PROTOCOL: Four groups of 20 rats each: 1) hypokinesia in cages; 2) hyperoxia (45% O₂); 3) joint effect of hypokinesia and hyperoxia; 4) controls. After 30 days 10 rats in each series were poisoned with carbon monoxide. Measurements: body weight; overall state; behavior; tolerance to CO; mortality rate.

IMMOBILIZATION METHOD: Cage (small-volume, metal screen)

RESULTS: The separate effects of hypokinesia and hyperoxia (45% O₂) did not change the general condition and behavior of the rats. The combined effects of hypokinesia and hyperoxia decreased tolerance to CO significantly, indicated by a considerable loss of body weight and a high mortality rate.

SOURCE: Space Biology and Aerospace Medicine 10(4): 121-123, 1976

AUTHOR(S): Ader, R., C.C. Beels, and R. Tatum

EXPERIMENT TITLE: Blood Pepsinogen and Gastric Erosions in the Rat

SUBJECTS: Male and female Wistar, Sprague-Dawley and Long-Evans adult rats

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Five groups: 1) male and female rats of all 3 strains were immobilized in wire cages into which a block of wire mesh slightly smaller than the cage was inserted to adjust the length of the cage to the size of the rat; physiological saline was injected sc into both hind legs before immobilization and food and water deprivation for 20 hr; 2) male rats of all 3 strains immobilized for 20 hr; 3) male control rats of all 3 strains; 4) female rats of all 3 strains immobilized for 20 hr; 5) female control rats. All rats were killed with ether, abdominal aorta blood withdrawn, and stomachs excised. Measurements: plasma pepsinogen levels; incidence, number and degree of gastric lesions.

IMMOBILIZATION METHOD: Cage (wire)

RESULTS: There were no strain differences in susceptibility to gastric erosions after immobilization among males. Wistar females had more gastric erosions per animal than Sprague-Dawley females. No control animals showed gastric erosions. There were no significant strain differences in pepsinogen levels. There was no significant correlation between pepsinogen level and number of erosions per animal; levels were higher in animals with gastric erosions. No lesions were found in control animals with high pepsinogen levels.

SOURCE: Psychosomatic Medicine 22: 1-12, 1960

AUTHOR(S): Ader, R.

EXPERIMENTAL TITLE: Gastric Erosions in the Rat: Effects of Immobilization at Different Points in the Activity Cycle

SUBJECTS: 44 Male Sprague-Dawley rats, (approx. 400 gm)

AREA OF STUDY: Digestive; Behavior

OBJECTIVES: In title

PROTOCOL: Predictable cycle activity patterns were obtained for 30 animals; 17 subjected to immobilization near their peak activity period; 13 immobilized during inactive phase. The animals were immobilized for 6 hr in flexible wire mesh. Animals sacrificed after immobilization and their stomachs examined. Measurements: incidence of gastric erosions

IMMOBILIZATION METHOD: Flexible wire mesh

RESULTS: Gastric erosions observed in 8 rats, all from the group immobilized during active phase.

SOURCE: Science 145: 406-407, 1964

AUTHOR(S): Ader, R.

EXPERIMENT TITLE: Behavioral and Physiological Rhythms and the Development of Gastric Erosions in the Rat

SUBJECTS: Adult male Sprague-Dawley rats

AREA OF STUDY: Behavior; Digestive

OBJECTIVES: In title

PROTOCOL: Six groups: 1) 17 rats immobilized for 6 hr at the beginning of their natural period of maximum activity; 2) 13 rats immobilized for 6 hr at the beginning of their natural period of least activity; 3) 37 rats had 3 cc of blood removed by cardiac puncture at initial, 2 wk and 4 wk sampling times, and tested for pepsinogen levels; 4) 30 rats under controlled light-dark schedule had blood samples taken every 4 hr for a 24 hr period by cardiac puncture, and tested for plasma pepsinogen levels and plasma corticosterone levels; 5) 8 rats deprived of food for 24 hr prior to 6 hr immobilization during maximum activity period; 6) 8 rats deprived of food for 24 hr prior to 6 hr immobilization during least activity period. Measurements: for groups 1 and 2, number of rats that developed gastric lesions.

IMMOBILIZATION METHOD: Not stated

RESULTS: Rats immobilized during the maximum activity period were more susceptible to gastric lesions than those immobilized during the least activity periods. The following experimental groups 3, 4, 5 and 6 were designed to delineate factors which may have contributed to the above results. A 24 hr rhythm in plasma corticosterone levels was found, but was not correlated with activity, or development of gastric lesions under immobilization stress. Plasma pepsinogen levels showed a 24 hr rhythm which was synchronized with activity, but did not correlate with altered gastric lesion susceptibility. The increased susceptibility shown by animals immobilized during a period of maximum activity was obtained even when the rats were protected by the presence of food in their stomachs.

SOURCE: Psychosomatic Medicine 29: 345-353, 1967

AUTHOR(S): Agadzhanyan, N.A. and G.V. Machinskiy

EXPERIMENT TITLE: Influence of Extended Hypokinesia on Altitude
Tolerance of White Rats

SUBJECTS: Male white rats (mean weight = 87.25 gm)

AREA OF STUDY: Nervous; Respiratory

OBJECTIVES: In title

PROTOCOL: Three groups: 1) control; 2) 10 days of hypokinesia; 3) 25 days of hypokinesia. Hypokinesia was created by placing the animals in a special apparatus containing 20 compartments; one rat per compartment. After hypokinesia, the experimental and control animals were placed in a temperature and pressure chamber in order to determine their altitude tolerance (rate of elevation 25 m/sec). Diet: standard mixture (lactic acid caseins, dry nutrient yeast, cornstarch, sunflower oil, a salt mixture and vitamins). Unlimited water supply. Measurements: weight; ECG; rectal temperature, and altitude at which convulsions appeared.

IMMOBILIZATION METHOD: Compartment

RESULTS: Regular changes in the weight of animals occurred during extended hypokinesia. Extended exposure to hypokinesia sharply decreased their tolerance for acute oxygen deficiency. The degree of this decrease in tolerance depended on the amount of time animals spent under conditions of hypokinesia. Progressive reduction of the altitude tolerance began only after 10-12 days.

SOURCE: Space Biology and Medicine 2(1): 32-37, 1968

AUTHOR(S): Akeson, W.H.

EXPERIMENT TITLE: Relationship Between the Aging Phenomena in Connective Tissue and the Connective Tissue Response to Immobility:
A Thermodynamic Approach

SUBJECTS: Rats, 19-28 wk old

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Two groups of paired littermates: 1) controls; 2) tail was immobilized in padded plaster cast for 4 to 12 wk. Tendons from the tails of both groups were measured for hydrothermal shrinkage at intervals between 63° and 67°.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: No significant differences were found in the shrinkage of collagen fibers between immobilized and free rat tail tendons.

SOURCE: Surgical Forum 14: 438-439, 1963

AUTHOR(S): Akeson, W.H. and D.F. LaViolette

EXPERIMENT TITLE: The Connective Tissue Response to Immobility: Total Mucopolysaccharide Changes in Dog Tendon

SUBJECTS: 36 Dogs

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: The right knee joint of each dog was immobilized by means of a threaded wire. The wire passed through the mid-tibia into the proximal femur posterior to the knee joint; the wire remained within the skin fold behind the knee. Fixation was maintained for 1-1/2, 4, 6 to 8, and 9 to 12 wk, after which the animals were killed with Nembutal and the quadriceps and patellar tendons were dissected free. Molar ratios of hexosamine, uronic acid, sulfate and nitrogen were established for the mucopolysaccharide extracted.

IMMOBILIZATION METHOD: Internal fixation with threaded wire

RESULTS: Total acid mucopolysaccharides were reduced in experimental limbs in the 4, 6-8 and 9-12 wk groups. Reduction in mucopolysaccharide was 20-40%.

SOURCE: Journal of Surgical Research 4(11): 523-528, 1964

AUTHOR(S): Akeson, W.H., D. Amiel, and D. LaViolette

EXPERIMENT TITLE: The Connective-tissue Response to Immobility: A Study of the Chondroitin-4 and 6-Sulfate and Dermatan Sulfate Changes in Periarticular Connective Tissue of Control and Immobilized Knees of Dogs

SUBJECTS: Adult mongrel dogs

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: The knee of each dog was immobilized by means of a threaded wire inserted through the proximal tibia into the femur; the wire remained within the skin fold behind the knee. Two wires were used for large animals. A nut was tightened down over the tibia after a position of flexion to 30° was obtained. After 9 wk, the dogs were returned to the vivarium for study. The animals were killed by an overdose of Nembutal, and then the periarticular connective tissue was dissected from the normal and immobilized knees. Measurements: total acid mucopolysaccharide concentration; hyaluronic acid concentration; chondroitin-4 and 6-sulfate; dermatan sulfate.

IMMOBILIZATION METHOD: Internal fixation with threaded wire

RESULTS: Total acid mucopolysaccharide concentration in normal periarticular connective tissue of the canine knee was shown to be 0.5%. Of the total acid mucopolysaccharide, 35.5% was hyaluronic acid, 40.5% was chondroitin-4 and 6-sulfate, and 19% was dermatan sulfate. The dermatan sulfate that was isolated was found to be hypersulfated with respect to hexosamine and had a molar ratio of sulfate/hexosamine of 1.30. After a period of immobilization, hyaluronic acid concentration was reduced on the immobilized side 39.5%; chondroitin-4 and 6-sulfate was reduced 32.2%. Dermatan sulfate was not changed in concentration at the end of this period of observation.

SOURCE: Clinical Orthopaedics and Related Research 51: 183-197, 1967

AUTHOR(S): Akeson, W.H., S.L.Y. Woo, D. Amiel, R.D. Coutts, and D. Daniel

EXPERIMENT TITLE: The Connective Tissue Response to Immobility: Biochemical Changes in Periarticular Connective Tissue of the Immobilized Rabbit Knee

SUBJECTS: 10 Male New Zealand white rabbits (3 kg)

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: The left knee of each rabbit was immobilized by means of a 2.4 mm threaded wire. The right knee served as a control. After a 9-wk period immobilization, periarticular connective tissue, articular cartilage and meniscus were analyzed. Measurements: total connective tissue; total hexosamine content; total GAG content (hyaluronic acid); chondroitin-4 and -6 sulfate; dermatan sulfate; total collagen content.

IMMOBILIZATION METHOD: Internal fixation with threaded wire

RESULTS: The gross appearance of the specimens from the control and immobilized knees differed. The immobilized tissue appeared dry and less glistening; fibro-fatty proliferation in the intercondylar notch was observed. Biochemical changes also occurred. The changes consisted of a marked reduction in concentration of water, hyaluronic acid, chondroitin-4 and -6 sulfate, but an insignificant decrease in dermatan sulfate. Total hexosamine was reduced significantly. There was no change in the total collagen content expressed either on the basis of concentration or on the basis of total periarticular connective tissue.

SOURCE: Clinical Orthopaedics and Related Research 93: 356-362, 1973

AUTHOR(S): Akeson, W.H., S. L-Y. Woo, D. Amiel, and J.V. Matthews

EXPERIMENT TITLE: Biomechanical and Biochemical Changes in the Periarticular Connective Tissue During Contracture Development in the Immobilized Rabbit Knee

SUBJECTS: 40 Male New Zealand white rabbits (3 kg)

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: The left knee of each rabbit was fixed in acute flexion with a pin fixation technique; a 2.4 mm diameter threaded stainless steel pin was passed through a drill hole in the mid-tibia and directed posterior to the knee but within the skin fold. The pin was then brought out through a small lateral thigh incision, bent acutely, and then hooked over the femur. The knee was forced into full flexion by tightening a nut securely against the tibia. The right knee served as a control. Groups of 10 rabbits each were maintained for 1, 2, 4 and 6 wk post-fixation and were then sacrificed. These groups of 10 were subdivided into 2 subgroups of 5 each for in vivo and in vitro studies on the arthrograph. Results from a previous study of 20 9-wk immobilized animals, 10 in vivo and 10 in vitro have been included in this report. Measurements: periarticular connective tissue (PCT) water, fat, total hexosamine, and total collagen content.

IMMOBILIZATION METHOD: Internal fixation by stainless steel pins

RESULTS: As restraint time increased, there were consistent trends of increase in joint stiffness and decrease in water and total hexosamine content in PCT. There were positive correlations between total hexosamine loss and biomechanical measurements in the contracture joints.

SOURCE: Connective Tissue Research 2(4): 315-323, 1974

AUTHOR(S): Akeson, W.H., D. Amiel, G.L. Mechanic, S.L.-Y. Woo,
F.L. Harwood, and M.L. Hamer

EXPERIMENT TITLE: Collagen Cross-Linking Alterations in Joint Contractures:
Changes in the Reducible Cross-Links in Periarticular
Connective Tissue Collagen After Nine Weeks of Immobilization

SUBJECTS: 6 Male New Zealand white rabbits (3 kg \pm 200 gm)

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: The left knee of each rabbit was fixed in acute flexion with a pin fixation technique; a 2.4 mm diameter threaded stainless steel pin was passed through a drill hole in the mid-tibia and directed posterior to the knee but within the skin fold. The pin was then brought out through a small lateral thigh incision, bent acutely, and then hooked over the femur. The knee was forced into free flexion by tightening a nut securely against the tibia. The right knee served as a control. All animals were maintained for 9 wk post-fixation, and were then sacrificed. Periarticular connective tissues were dissected free from immobilized and control knees. Measurement: collagen cross-links.

IMMOBILIZATION METHOD: Internal fixation by stainless steel pins

RESULTS: There was a significant increase in the NaBH_4 reducible intermolecular cross-links of the periarticular connective tissue. The major cross-links which increased during restraint were dihydroxylysinoxidation products, hydroxylysinoxidation products, and histidinohydroxymerodesmosine. There was no change in the hydroxylysine/lysine ratio between the restrained and control periarticular connective tissue collagen during the restraint period.

SOURCE: Connective Tissue Research 5: 15-19, 1977

AUTHOR(S): Alder, A.B., G.N.C. Crawford, and R.G. Edwards

EXPERIMENT TITLE: The Effect of Limitation of Movement on Longitudinal Muscle Growth

SUBJECTS: Rabbits, mixed strain, 2-4 wk old

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) immobilization of the foot in dorsi-flexion for 4-25 wk, 4 rabbits, wire threaded through holes drilled transversely through the shaft of the tibia about half way along its length, another through the metatarsals just distal to the insertion of the tendon of the tibialis anterior and tied together; 2) limitation of the plantar-flexion for up to 42 wk, 4 rabbits, a length of chain joining the tibia to the foot enabled the latter to be fully dorsi-flexed, but prevented plantar-flexion beyond an angle of 90° with the leg. The opposite leg in both groups served as a control. Myography was used to obtain the data for the tension-length curves of the control muscle. Measurements: lengths of the muscle belly, distance of the insertion of the tendon of tibialis anterior from the distal border of the crural ligament, tendon of the tibialis anterior, resting and active isometric tetanic tensions.

IMMOBILIZATION METHOD: Internal fixation by wire

RESULTS: Group 1) prevention of movement resulted in a considerable diminution in the longitudinal growth of the muscle belly of tibialis anterior, and isometric tetanic tensions equivalent in degree to those of the control muscle of the normal leg were exerted at shorter belly lengths and through a reduced range of movement of the foot. Resting tension rose rapidly as soon as the muscles were stretched beyond their maximum length in vivo under the experimental conditions. Tendon length increased slightly as did the length of the tibiae. Group 2) similar effects as group 1 but less pronounced: diminution in excursion of the belly of tibialis anterior, maintained for a period up to 42 wk. Decrease in longitudinal growth of the muscle belly. Developed tension-length curves of the experimental muscles were diminished in length in comparison with control, maximum developed tension of the experimental muscle was about 70% that of control. Resting tension appeared at a length considerably less than that when it is first appreciable in normal muscle belly.

SOURCE: Proceedings of the Royal Society. Series B: Biological Sciences 150: 554-562, 1959

AUTHOR(S): Aleksina, L.A.

EXPERIMENT TITLE: The Effect of Hypokinesia and Hypodynamia on Intra-organic Cardiac Arteries

SUBJECTS: 20 Rabbits

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 5 controls; 2) 15 rabbits hypokinetic for 2-12 wk in small cages. The cardiac arteries were injected with India ink. The heart was cut into 4 parts and longitudinal and cross sections were prepared for each part.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: After hypodynamia and hypokinesia, there was a change in the arterial bed of the heart. After 2 weeks, the myocardial capillaries constricted considerably and their course became tortuous. There was gradual dilatation of myocardial capillaries to 10 microns with impaired parallel between the course of capillaries and muscle fibers with the appearance of tortuosity and uneven filling of the vessels. After 12 weeks, the changes progressed with impairments of the myocardial architectonics.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 61(11): 92-95, 1971

AUTHOR(S): Aleksina, L.A.

EXPERIMENT TITLE: Microcirculatory Bed of the Pericardium Under Hypokinesia Conditions

SUBJECTS: Rabbits (2.5-3 kg)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Hypokinesia was created by placing the animals in restraint cages. After one to 12 wk the animals were sacrificed using ether fumes. The heart and pericardial sac were fixed in a 12% solution of neutral formalin. The microcirculatory bed of the pericardium was studied using silver nitrate impregnation, injection of Paris blue into the vessels, and subsequent clarification of all the preparations in glycerine.

IMMOBILIZATION METHOD: Cage

RESULTS: The microcirculatory bed of the pericardium showed certain morphological changes during hypokinesia. After 2 wk, disruption of the capillary-venule link in the microcirculatory bed occurred. Prolonged hypokinesia led to anatomical changes in all links of the microcirculatory bed.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 69(10): 45-49, 1975.

AUTHOR(S): Allik, T.A. and L.I. Karpova

EXPERIMENT TITLE: Dependence of Altitude Tolerance of Animals on the State of Phosphorylation Processes

SUBJECTS: 60 White male rats

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title:

PROTOCOL: Two groups: 1) control; 2) experimental rats were kept for 7 wk in special chambers which limited their mobility. A 2.4% solution of sodium amytal (7 mg/100 gm) was injected into both groups. Measurements: maximum work capacity, evaluated on the basis of the maximum time of swimming with a load equal to 15% of the weight of the animals; oxygen consumption at rest; relation of free and phosphorylating oxidation, characterized by the relation between amytal-resistant and amytal-sensitive respiration; altitude tolerance at 12,000 m at 20-21°C.

IMMOBILIZATION METHOD: Chamber

RESULTS: By the end of the experimental period the oxygen consumption at rest in the control rats was 159.0 ± 6.7 ml O₂/hr per 100 gm of weight of the animals. In the rats remaining in a state of hypokinesia the oxygen consumption was sharply reduced in comparison with the control and was 94.4 ± 23.3 ml O₂/hr per 100 gm of weight. The fraction of amytal-resistant oxidation in the total consumption of oxygen for the control rats in this case was $43.2 \pm 2.16\%$, and for the experimental animals it was $76.3 \pm 2.0\%$. Therefore, the fraction of amytal-resistant oxidation in the control rats was 56.8% of the total oxygen consumption; however, for the rats with limited mobility it decreased by more than a factor of 2 to $23.7 \pm 2.0\%$. The activity and altitude tolerance fell in parallel with a decrease of the phosphorylating respiration.

SOURCE: Space Biology and Medicine 1(3): 56-58, 1967

AUTHOR(S): Allison, N. and B. Brooks

EXPERIMENT TITLE: Bone Atrophy: An Experimental and Clinical Study of the Changes in Bone Which Result from Non-use

SUBJECTS: Dogs

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Three methods were employed to prevent use of the foreleg: 1) section of the brachial plexus - 13 experiments; 2) excision of upper end of the humerus - 7 experiments; 3) plaster-of-Paris fixation - 4 experiments. In each group of experiments the results of non-use for varying periods of time - up to 314 days - were studied. For the study of the effect of non-use on regeneration, a section of each ulna was removed from some of the subjects used under the non-use methods; the resulting defects were bridged by transplants of atrophied bone placed in the non-atrophied ulna, and non-atrophied bone placed in the atrophied ulna. Measurements: x-ray investigations; gross and microscopic anatomy; chemical composition; breaking strength; regeneration.

IMMOBILIZATION METHOD: Plaster of Paris cast; Denervation

RESULTS: Changes(due to non-use) in 1) x-ray photographs: shadows of the trabeculae became less defined (7 to 30 days); decrease in diameter of bone shaft, increase in diameter of medullary canal (30 to 100 days); very few and small trabeculae, bone of shaft further diminished (100 to 314 days); 2) gross and microscopic anatomy: initial changes described above were more pronounced; also, cortical bone of the shaft lost its compact structure and became porous; 3) chemical composition: non-use had no effect upon the chemical composition of the bone matrix; 4) the strength of the bones: marked difference in the breaking strength of bones of the used and non-used extremities - the bones of the non-used extremity break more readily; 5) regeneration of bone: no differences were observed.

SOURCE: Surgery, Gynecology and Obstetrics 33: 250-260, 1921

AUTHOR(S): Altman, J.L., W.E. Whitehead, and A. Rechtschaffen

EXPERIMENT TITLE: Effects of Five Hours of Restraint Stress on Subsequent Sleep in the Rat

SUBJECTS: 8 Adult male Sprague-Dawley rats

AREA OF STUDY: Behavior

OBJECTIVES: In title

PROTOCOL: Restraint: 5 hr. Pretreatment: EEG and EMG electrodes were implanted. 3 wk later, rats were placed in sound-attenuated, temperature-regulated recording cages for 4 days of habituation. Restraint technique: 4 rats were placed astride a 6.3 cm diameter steel pipe, their backs were taped down, and their feet were taped together underneath the pipe; 4 rats served as controls. All rats were sleep-deprived. Measurements: slow sleep; total sleep; paradoxical sleep.

IMMOBILIZATION METHOD: Steel pipe and adhesive tape

RESULTS: No significant slow sleep differences between the 2 groups were seen in the 12-hr poststress recording period. Stressed rats did show less paradoxical sleep than controls during the first 6-hr posttreatment.

SOURCE: Psychonomic Science 26(3): 152-154, 1972

AUTHOR(S): Amiel, D., W.H. Akeson, F.L. Harwood, D.A. Schmidt, and G.L. Mechanic

EXPERIMENT TITLE: Effect of Low Dosage Schedule of D-Penicillamine on Collagen Cross-Linking in a Nine Week Immobilized Rabbit Knee

SUBJECTS: 7 Male New Zealand white rabbits (3±.2 kg)

AREA OF STUDY: Musculoskeletal; Pharmacology

OBJECTIVES: In title

PROTOCOL: The left knee of each rabbit was fixed in acute flexion with a pin fixation technique; a 2.4 mm diameter threaded stainless steel pin was passed through a drill hole in the mid-tibia and directed posterior to the knee but within the skin fold. The pin was then brought out through a small lateral thigh incision, bent acutely, and then hooked over the femur. The knee was forced into full flexion by tightening a nut securely against the tibia. The right knee served as a control. Starting on day 10 post-fixation, rabbits were given 60 mg/kg penicillamine 3 times weekly. The animals were sacrificed after 9 wk, and peri-articular connective tissues were removed for analysis. Measurements: body weight; collagen cross-links.

IMMOBILIZATION METHOD: Internal fixation by stainless steel pins

RESULTS: There was a significant decrease in the formation of cross-links in the control and immobilized knee in the treated rabbits vs. the untreated ones. Penicillamine blocked the increase in dihydroxylysinoxorleucine, hydroxynorleucine, and histidinohydroxymersodesmosine. The weight of the animals remained stable or increased slightly.

SOURCE: Connective Tissue Research 5: 179-183, 1977

AUTHOR(S): Andrianova, L.A.

EXPERIMENT TITLE: Effect of Hypokinesia on the Hypothalamic-Hypophyseal Neurosecretory System in Rats

SUBJECTS: 70 Rats

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 28 controls; 2) 42 experimental rats were kept in special restrictive cages. Rats were examined on days 3, 15, 45 and 60 after hypokinesia, then decapitated. Morphological study involved the extracted brain fixed in 10% formalin solution; the Sawyer method was used to determine antidiuretic activity (ADA) of blood plasma and hypothalamus extracts from change in permeability of the bladder wall of a grass frog. Diet: unlimited water and dry fodder (sunflower oil and fish fat added).

IMMOBILIZATION METHOD: Cage (restrictive)

RESULTS: On day 3, supraoptic and paraventricular nuclei neurons showed variability in the neurosecretion content, plus a large amount of extracellular secretion. In the posterior lobe of the hypophysis, neurosecretory matter content was increased, plus a great quantity of granular secretion and Herring bodies. On day 15, there were no differences in the neurosecretion content in the frontal nuclei of the hypothalamus, but there was a decrease in the quantity of neurosecretory substance in the posterior lobe of the hypophysis. On days 45 and 60, the quantity of neurosecretion in the supraoptic and paraventricular nuclei and in the posterior lobe of the hypophysis was normal. A statistically reliable increase in blood plasma ADA was seen on day 15; by day 45 its level had decreased somewhat, though still quite high. On day 65, the blood plasma ADA approached the initial level.

SOURCE: Space Biology and Medicine 5(5): 37-41, 1971

AUTHOR(S): Andrzejewska, A., S. Kurasz, and J. Gorski

EXPERIMENT TITLE: Ultrastructure of Different Types of Skeletal Muscle Fibers of Hypokinetic Rats

SUBJECTS: Male Wistar rats (250-260 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: The animals were kept for 30 days in plexiglas restraint cages and had free access to commercial diet pellets and water. The types of skeletal muscle removed from the animals included: 1) the most superficial layer of the vastus lateralis (the white, fast-twitch, glycolytic muscle); 2) the deepest layer of the same muscle (the red, fast-twitch, oxidative-glycolytic muscle); 3) the soleus (the intermediate, slow-twitch, oxidative muscle). The samples were fixed, embedded, sectioned and slides prepared for light microscope and electron microscope examination.

IMMOBILIZATION METHOD: Cage (plexiglas, 18 x 5 x 4.5 cm)

RESULTS: Light microscopy: the hypokinesia did not produce any significant changes in the white muscle. In the red and intermediate muscles the diameter of many fibers was reduced. The number of nuclei was often increased and some translocated to the center of the fiber. The amount of endomysial connective tissue was slightly increased. Electron microscopy: most of the white muscle fibers remained unchanged. In the red muscle the Z lines of many fibers were irregular and disintegrated contractile elements were replaced by sarcoplasmic reticulum. The intermediate fibers were similarly altered as those of the red fibers. Overall, the most severely damaged fibers were of the intermediate muscle fibers followed by the red and white muscle fibers.

SOURCE: Acta Physiologica Polonica 29(3): 291-295, 1978

AUTHOR(S): Antipenko, A.Ye., Yu.A. Bubeyev, B.F. Korovkin, and N.P. Mikhaleva

EXPERIMENT TITLE: cAMP System in Muscle Tissue During Prolonged Hypokinesia

SUBJECTS: 60 White mongrel rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinesia created by placing the rats in special booths which restricted their movement. Muscle tissue (m. gastrocnemius) was studied on days 2, 5, 24, 37 and 70 of hypokinesia and on day 7 of readaptation. Measurements: cyclic AMP levels; activities of phosphodiesterase and adenylyl cyclase.

IMMOBILIZATION METHOD: Booth (small)

RESULTS: Initially, cyclic AMP levels and the activities of phosphodiesterase and adenylyl cyclase in muscle tissue were increased. The values for these indices were roughly equal for controls and experimental animals during the adaptation period, but on the 70th day of hypokinesia the cAMP levels dropped, phosphodiesterase activity increased, and the stimulative effect of epinephrine on the activity of adenylyl cyclase decreased. The studied indices normalized during the readaptation period.

SOURCE: Voprosy Meditsinskoi Khimii 24(6): 765-768, 1978

AUTHOR(S): Antoon, J.W. and R.V. Gregg

EXPERIMENT TITLE: The Influence of Body Temperature on the Production of Ulcers of Restraint in the Rat

SUBJECTS: Female Sprague-Dawley rats (175±5 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Animals were kept in the laboratory an average of 6 days and not less than 3 days before the experiment; the laboratory was maintained at $22\pm 1^{\circ}\text{C}$. An artificial night-day cycle was used. All rats were food deprived for 24 hr prior to the experiment. 3 groups: 1) 27 experimental animals restrained for 18 hr in a 38 x 46 x 21 cm incubator (ambient temperature controlled to maintain rat rectal temperature of $38\pm 0.5^{\circ}\text{C}$); 2) 30 controls restrained for 18 hr at room temperature ($22\pm 1^{\circ}\text{C}$); 3) 10 controls unrestrained in an 18 x 46 x 21 cm cage. Restraint technique: the animals were bound on their sides to an insulated 10 by 25-cm stainless steel platform with cloth adhesive tape. At the end of the experimental period, the animals were killed by a blow to the cervical vertebrae and the stomachs were removed. Measurements: body temperature; gastric ulceration.

IMMOBILIZATION METHOD: Platform and tape

RESULTS: Body temperatures of rats restrained at room temperature fell 5.0°C in the first 5 hr; gastric ulceration was 100%. When body temperatures were maintained at 38°C , only 26% developed ulcers.

SOURCE: Gastroenterology 70 (5, Pt.1): 747-750, 1976

AUTHOR(S): Artyukhina, T.V.

EXPERIMENT TITLE: State of the Hypothalamic-Hypophyseal Neurosecretory Structures During Hypokinesia

SUBJECTS: 145 Rats

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 70 controls; 2) 75 experimental rats kept in small restraint cages. The neurons of the supraoptic and paraventricular nuclei were taken from the control and experimental rats on day 1, 3, 5, 10, 14, 20, 30, 45 and 60 of the experiments. Measurements: localization and content of the neurosecretory material; RNA.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: The animals subjected to hypokinesia exhibited changes in the RNA and neurosecretion contents of the hypothalamic-hypophyseal neurosecretory structures. There was an increase in RNA content in the secretory-nucleus cells on day 1, 3 and 14 of hypokinesia. Activation of the secretory function and of secretion release occurred during the first 2 wk. Normalization occurred during longer exposures to hypokinesia (20 days or more).

SOURCE: Eksperimental'nye Issledovaniya Gipokinezii, Izmenennoi Gazovoi Sredy, Uskorenii, Peregruzok i Drugikh Faktorov (ed. by V.V. Parin et al), 1968, pp. 3-5.

AUTHOR(S): Arutyunyan, R.S. and G.A. Nasledov

EXPERIMENT TITLE: Responses of Muscle Spindles of "Fast" and "Slow" Muscles to Mechanical Stimulation During Hypokinesia

SUBJECTS: Cats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Hypokinesia was produced by applying a plaster bandage to the right rear extremity of the animal. The coxofemoral, knee and talocrural joints were fixed in a semi-bent position. The extensor digitorum longus was used as the fast muscle and the soleus as the slow muscle. The experiment was started in 2-5 weeks after immobilization. The afferent activity of the primary or secondary ending was shunted from a split single post-radicular bundle. A recording was made of the spontaneous impulse activity, background activity with constant stretch of the muscle by a weight of 100 gm, activity during dynamic and static phases of stretch with varying rate and amplitude, as well as responses to the vibration stimulation.

IMMOBILIZATION METHOD: Plaster bandage

RESULTS: The spontaneous activity of spindles in both muscles in hypokinesia remained unchanged. The background activity and frequency of discharges in the dynamic and static phases of stretching in the primary and secondary endings was much higher in immobilized muscles than in controls. This increase in spindle activity was more pronounced in the slow muscle.

SOURCE: Neirofiziologiya 10(2): 186-192, 1978

AUTHOR(S): Asymaolov, B.F. and A.D. Voskresenskiy

EXPERIMENT TITLE: Effect of Two-Week Hypokinesia on the Cardiovascular Responses of Dogs during Orthostatic Tests and Exposure to Transverse Accelerations

SUBJECTS: Female dogs (6-12 kg)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Dogs were fixed by plaster dressings to a trapezoidal metal frame while lying on their stomachs and kept in this position for 14-16 days. After 10-14 days immobilization, 4 dogs while under morphine-hexanal anesthesia had catheters introduced into the aortic arch through the carotid artery and into the atrium cordis dextrum through the jugular vein. Immediately after introduction of the catheters and on the 1-2 days which followed, five repeated orthostatic tests were made up to 10 min in duration at 5-min intervals. Blood pressure and ECG were recorded. Catheters were then removed and the wound tightly sewn up. On the 3 last days of immobilization the procedures were repeated. The tolerance to a linearly increasing transverse acceleration was determined in dogs 6-10 days before applying the plaster dressing and on the day it was removed.

IMMOBILIZATION METHOD: Metal frame

RESULTS: Orthostatic tests demonstrated variations in the pulse rate and arterial pressure. Exposure to accelerations was accompanied by higher tachycardia with a more pronounced inverse relation between changes in pulse rate and arterial pressure.

SOURCE: Space Biology and Medicine 2(4): 55-63, 1968

AUTHOR(S): Bagramyan, E.R.

EXPERIMENT TITLE: The Content of Ascorbic Acid in the Adrenal Glands and the Production of Corticosteroids In Vitro in Irradiated, Immobilized, and Hypophysectomized Rats

SUBJECTS: Male rats

AREA OF STUDY: Endocrine; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Four groups: 1) irradiated, lethal dose of x-rays (800 r), with rats killed 5-8 days postirradiation; 2) hypophysectomized, operation was conducted 48 hr and 2 wk prior to testing; 3) immobilized, tied to a stand upside down for 1 hr, after which rats were killed; and 4) controls, killed immediately. Two series of experiments were conducted. In the 1st, the content of ascorbic acid in the left adrenal gland was determined in the animals of all 4 groups. In the 2nd series of experiments, both adrenals were removed to determine the corticosteroids formed under incubation conditions in experiments in vitro. Measurements: ascorbic acid in adrenal glands; group 1 only - body weight; number of leucocytes in the peripheral blood; weight of the thymus and adrenal glands.

IMMOBILIZATION METHOD: Tied upside down to a stand

RESULTS: One-hour restraint decreased the content and concentration of ascorbic acid in the adrenals and increased production of corticosteroids. The biosynthetic capacity of the adrenal tissue increased. Adrenal gland weight did not change. Hypophysectomy produced a sharp increase in adrenal weight and in the amount of ascorbic acid in the adrenals. Ascorbic acid concentration increased, but corticosteroid production decreased in in vitro experiments. Irradiation increased adrenal weights and their ascorbic acid content during the peak period of radiation sickness; ascorbic acid concentration did not change. Corticosteroid production increased in in vitro experiments.

SOURCE: Problemy Endokrinologii i Gormonoterapii 12: 66-72, 1966

AUTHOR(S): Bajusz, E.

EXPERIMENT TITLE: Disuse Atrophy of Skeletal Muscle in the Rat Aggravated by Cortisol and Various Stress Conditions

SUBJECTS: 100 Young female Sprague-Dawley rats (82-92 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Immobilization: 21 days, left hind limb immobilized in extended position in a plaster of Paris cast. Diet: food/water ad libitum. 10 groups: 1) untreated control (initial), killed the day the experiment commenced; 2) untreated (final); 3) immobilization only. Subjects in groups 4-10 all underwent immobilization, and received the following additional treatment: 4) cortisol acetate (COL-Ac); 5) partial fasting; 6) partial fasting + COL-Ac; 7) exposure to cold; 8) exposure to cold (3°C) + COL-Ac; 9) formaldehyde + COL-Ac; and 10) restraint by taping to a board (neuromuscular strain) + COL-Ac. After the 21st day, the rats were killed with chloroform and the triceps surae muscles were dissected. Measurements: muscle and body weight.

IMMOBILIZATION METHOD: Cast

RESULTS: Immobilization alone produced diminution in the rate of somatic growth (group 3) which was more marked in animals submitted to immobilization together with stressors and/or treatment with COL-Ac (groups 4-10). The weights of the triceps surae muscles of the disused side in rats treated with COL-Ac and/or various stressors (groups 4-10) were decreased to below the initial values. The decrease in the intact triceps surae muscle weight paralleled that of the body weight in immobilized animals, with or without exposure to stressors and/or COL-Ac. There was no marked variation in the degrees of muscle atrophy caused by various stressors. The addition of COL-Ac produced a greater degree of atrophy, which was still independent of the type of stressor used.

SOURCE: Canadian Journal of Biochemistry and Physiology 36: 825-831, 1958

AUTHOR(S): Balsam, A.

EXPERIMENT TITLE: Effect of Chronic Immobilization on the Turnover and Metabolism of L-Thyroxine and Thyroid Function in the Rat

SUBJECTS: Adult male Sprague-Dawley rats

AREA OF STUDY: Endocrine; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Rats were immobilized in plaster of Paris casts, extending from the distal tibia to the pelvis. Animals were maintained in separate cages under constant temperature conditions for 17 days. Phenolic ring-labeled ^{125}I -thyroxine was used as tracer, over 90% of which was L-thyroxine and less than 5% iodide. Diet: Purina Lab Chow; water ad lib. Measurements: urine; feces; muscle weight; body weight; total plasma thyroxine concentration; serum protein-bound iodine.

IMMOBILIZATION METHOD: Plaster of Paris cast

RESULTS: Immobilization resulted in: 1) significant muscle atrophy; 2) increased metabolic clearance of thyroxine due to increased urinary deiodinative and fecal clearances; 3) diminished serum protein-bound iodine concentration; 4) plasma fractional removal rate; 5) total and hepatic distribution spaces; 6) liver: plasma ratio of thyroxine. There were no changes in: 1) absolute thyroxine degradation; 2) intrinsic cellular hormonal clearance; and 3) isotopic measurements of thyroid function.

SOURCE: Endocrinology 91(2): 355-361, 1972

AUTHOR(S): Baranski, S., Z. Edelwejn, and M. Wojtkowiak

EXPERIMENT TITLE: Hemodynamic and Bioelectric Disturbances in Striated Muscles of Rats Subjected to Accelerative Forces After a Period of Hypokinesia

SUBJECTS: Male Wistar rats

AREA OF STUDY: Muscular

OBJECTIVES: Investigate the effect of a period of hypokinesia on the tolerance to accelerative forces applied for various durations

PROTOCOL: Subjects divided into four groups: 1) control; 2) acceleration centrifuged +5 G_z for 15 min or 1, 2 or 3 hr; 3) hypokinetic, immobilized for 2 mo; and 4) hypokinetic-acceleration (group 3 conditions followed by group 2 conditions). The animals were given 50 mc/100 gm ¹³¹I-albumin; after 1 hr, animals in groups 2 and 4 were subjected to the acceleration profiles. Measurements: electromyography; radioactivity of hind leg and foreleg muscles; distribution of radionuclide.

IMMOBILIZATION METHOD: Not stated

RESULTS: Measurements of radioactivity of ¹³¹I-albumin in muscle showed that in animals subjected to acceleration forces (+5 G_z) for more than 1 hr a redistribution of albumin was seen. Hemodynamic disturbances were earlier and more profound in animals subjected to the associated influences of hypokinesia and acceleration. Visible reduction in bioelectric activity of the muscle was observed in immobilized animals when subjected to acceleration forces. Immobilized animals demonstrated a markedly lower tolerance to acceleration, they survived only 22-37 min.

SOURCE: Space Life Sciences 2(3): 400-403, 1970

AUTHOR(S): Baranski, S., K. Kwarecki, S. Szmigielski, and J. Rozynski

EXPERIMENT TITLE: Histochemistry of Skeletal Muscle Fibers in Rats
Undergoing Long-Term Experimental Hypokinesia

SUBJECTS: 15 Mature male Wistar rats (250 ± 20 gm)

AREA OF STUDY: Muscular

OBJECTIVES: Evaluate morphochemical change of skeletal muscles after hypokinesia and compare with change following muscle denervation.

PROTOCOL: Three groups of 5 rats each: 1) control; 2) hypokinetic, kept in small cages with a constant temperature of $20^0 \pm 2^0\text{C}$; 3) muscle denervation (cutting of sensory and motor nerves). Control and experimental groups were observed for 6 wk. Following decapitation and bleeding, small pieces of the central part of the musculus quadriceps were studied. Diet: ad libitum. Measurements: fiber diameter; enzymes.

IMMOBILIZATION METHOD: Cage (small); Denervation

RESULTS: Restraint changed the morphochemical picture of muscle fibers. More connective tissue, reduced glycogen concentration, decreased cytochrome oxidase, and increased lactate dehydrogenase activities were seen, mainly in red fibers. Biochemical and functional changes caused by immobilization rapidly disappeared after return to normal activity. Denervation of sensory and motor nerves caused marked changes in enzyme activity, particularly in red fibers. Cytochrome oxidase activity was lower after cutting the sensory nerve and higher after cutting the motor nerve.

SOURCE: Folia Histochemica et Cytochemica 9: 381-386, 1971

AUTHOR(S): Baranski, S., Z. Edelwejn, and M. Wojtkowiak

EXPERIMENT TITLE: Displacement of Plasma Protein and Conduction Velocity
in Rats Under Action of Acceleration Forces and Hypokinesia

SUBJECTS: 70 Wistar rats (200-250 gm)

AREA OF STUDY: Circulatory; Nervous

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 40 rats immobilized in special cages for 4 wk;
2) 30 controls. After 4 wk, they were centrifuged at +5Gz for periods of
15 min, 1, 2 or 3 hr. Before centrifugation, all groups were injected
with ^{51}Cr -globulin. Measurements: muscles of hindlimbs and forelimbs for
radioactivity; conduction velocity of the sciatic nerve.

IMMOBILIZATION METHOD: Cage

RESULTS: Acceleration of +5Gz for 15 min to 2 hr did not induce penetration
of the vascular wall by macromolecular proteins such as globulins. Hypo-
kinesia did little to favor penetrability of the vessels by macromolecular
proteins. Immobilization for 4 wk induced a statistically significant
reduction in the conduction velocity of the sciatic nerve.

SOURCE: Postepy Astronautyki 5(2): 61-70, 1972

AUTHOR(S): Baranski, S., Z. Edelwejn, W. Stodolnik-Baranska, and Z. Sarol

EXPERIMENT TITLE: Morphologic and Electromyographic Investigations on the Influence of Hypodynamia on the Functional Efficiency of Muscles

SUBJECTS: 30 Male Wistar rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 10 controls; 2) 20 experimental rats immobilized in specially constructed containers for period of 1 up to 2 mo. Both groups were subjected to extreme physical exhaustion using the swimming test. Electromyographic registration was carried out directly after the period of immobilization and following the swimming test. The ischiadic nerve was stimulated with needle electrode rectangular stimuli (amplitude of 50 V, 0.3 msec duration and 2 cycles/sec). The potentials were registered from the gastrocnemius muscle. Muscles were then excised and a part was examined histologically. Another part was used for electronomicroscopy.

IMMOBILIZATION METHOD: Container

RESULTS: Immobilization caused an increase in the percentage of polyphasic potentials and the appearance of potentials of very short duration and low amplitude. Following physical effort the transformation of polyphasic potentials into triphasic and even simple potentials was observed in immobilized animals. The potentials of short duration became longer. The opposite was true in the control group. After 2 months of immobilization the number of mitochondria was reduced and internal structure obscured. Content of glycogen was distinctly reduced and structure of myofibrils obscured. There was a tendency toward normalization after physical effort expressed by an increase of amplitude and duration of the registered potentials.

SOURCE: Revue de Medecine Aeronautique et Spatiale 12(46): 380-382, 1973

AUTHOR(S): Baranski, S., W. Baranska, and M. Marciniak

EXPERIMENT TITLE: Changes in Pigeon Muscles During Long-Term Hypokinesia

SUBJECTS: Pigeons

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 6 and 12 month hypokinesia; 2) 12 month hypokinesia, followed by 1 hr flight; 3) controls. The m. pectoralis and m. supracoracoideus muscle was taken from live birds under anesthesia. Measurements: frequency of lipid droplets, glycogen content, muscle atrophy.

IMMOBILIZATION METHOD: Not stated

RESULTS: In both muscles similar morphological changes, of varying intensity, were found. In both muscles an increased frequency of lipid droplets was apparent as compared with control, after 6 mo of hypokinesia. The droplets appeared generally in the red fibers, formed agglomerations after the 12 mo period, and often contained homogeneous material of high electron density. Under 12 mo hypokinesia, the number of glycogen granules increased both in the red and white fibers; a significant increase also occurred after 6 mo. No statistically significant changes in the number of granules were found in pigeons subjected to physical exercise. In both muscles of birds subjected to physical effort after 12 mo hypokinesia muscular atrophy was found, more pronounced in the m. supracoracoideus, and involving mainly the white fibers.

SOURCE: Annals of the Medical Section of the Polish Academy of Sciences 21 (1-2): 9-10, 1976.

AUTHOR(S): Baranski, S., Z. Edelwejn, and W.S. Baranska

EXPERIMENT TITLE: Effect of Long-Term Hypodynamia and Hypokinesia on the Functional State and Ultrastructure of Striated Muscles

SUBJECTS: Wistar rats, Pigeons

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Four groups: 1) control rats; 2) hypokinetic rats for durations up to 6 mo; 3) control pigeons; 4) hypodynamic pigeons for durations up to 1 yr. Electrocardiographic and electromyographic investigations were carried out on all animals. Routine morphological and histological examinations of striated muscle tissue were carried out. After immobilization, some of the rats were subjected to extreme physical exercise in the form of swimming for 1 to 2 hr daily. Measurements: nerve conduction velocity; changes in muscle tissue ultrastructure; changes in histochemical reactions.

IMMOBILIZATION METHOD: Not stated

RESULTS: In hypokinetic rats, atrophy developed, but not in hypodynamic pigeons. Glycogen decreased in rats after long term hypokinesia but increased in hypodynamic pigeons. In the myocardium of both rats and pigeons, no change in glycogen was found. Glycogen levels decreased greatly in rats subjected to exercise after immobilization. Intensity of reactions to succinic dehydrogenase diminished with long term hypokinesia. Ultrastructural investigations showed degeneration in the mitochondria, with disintegrated cristae and increased number of lysosomes in hypokinetic rats. Exercise partly reversed this trend. Analysis of electromyographic tracing showed two types of changes. In some rats the proportion of polyphasic potentials increased without changes in the amplitude, in some the potentials decreased and amplitude diminished. In pigeons subjected to hypodynamia, no such extensive changes were observed as in hypokinetic rats.

SOURCE: Artificial Satellites 11(1): 15-28, 1976

AUTHOR(S): Barbashova, Z.I. and O.I. Tarakanova

EXPERIMENT TITLE: Rat Reaction to Hypokinesia After Prior Adaptation to Hypoxia

SUBJECTS: Male mongrel rats

AREA OF STUDY: Muscular; Circulatory

OBJECTIVES: In title

PROTOCOL: Six groups: 1) 30 day adaptation to hypoxia; 2) 80 day adaptation to hypoxia; 3) 30 day hypokinesia; 4) 50 day hypokinesia; 5) 80 day adaptation to hypoxia plus 50 day hypokinesia (80 day hypoxia training, of which first 30 days for effect of hypokinesia and last 50 days in combination with it); 6) control animals (30, 50 and 80 days). To create hypokinesia the rats were placed in individual box cages of plexiglas. Animals were adapted to hypoxia by placing them in a decompression chamber for 5 hr daily for a period of 1 mo. The first day of altitude simulation was 2,500 m and was increased daily by 500 m until it reached 7,500 m. Each week the animals were weighed. At the end of the experimental period there was a determination of erythrocyte and hemoglobin content in the blood. Bodily and CNS resistance to the effect of hypoxia was determined after the experimental period by placing the animals in a decompression chamber at a simulated altitude of 12,500 m to see if they could survive for a period of 5 min. 24 hr after these experiments the rats were decapitated and the resistance of the skeletal muscles measured.

IMMOBILIZATION METHOD: Cage (plexiglas)

RESULTS: In respect to body weight, hypoxia-adapted animals subjected to hypokinesia lost 14% of their body weight compared to a 27% loss in animals subjected to hypokinesia alone. All of the hypoxia adapted-hypokinetic animals tolerated the 5 min at 12,500 m whereas only 60% of the controls tolerated this exposure. An analogous picture was observed in determining the resistance of skeletal muscles. The hypoxia adapted hypokinetic animals had the highest resistance to injury. Hypoxia adaptation caused a rise in hemoglobin content and the erythrocyte count. After 50 days of hypokinesia, there was a decrease in the erythrocyte count and hemoglobin content as compared to the controls. In rats with 50 days of hypokinesia after prior hypoxia adaptation, levels were the same as in controls.

SOURCE: Fiziologicheskii Zhurnal SSSR Imeni I M Sechenova 60(3): 434-439, 1974

AUTHOR(S): Barbashova, Z.I. and T.V. Tavrovskaya

EXPERIMENT TITLE: Effect of Hypokinesia on the State of the Thyroid Gland in Rats Previously Adapted to Hypoxia

SUBJECTS: Male rats

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Four groups: 1) control; 2) hypokinesia - 50 days, 24 hr daily; 3) adaptation to hypoxia - 5 hr daily, except Sundays, for 1 mo in a pressure chamber at an altitude of up to 7500 m, and for the next 50 days at an altitude of 6500 m for 3 hr daily on alternate days; 4) adaptation to hypoxia and hypokinesia - 50 day period of adaptation to hypoxia was combined with hypokinesia. Thyroid glands were removed immediately after decapitation. Measurements: thyroid function, assessed from the height of the follicular epithelial cells, the quantitative ratio between epithelium, colloid, and connective tissue, the density of the colloid, and the presence of "zones of resorption".

IMMOBILIZATION METHOD: Cage (individual box)

RESULTS: Thyroid function was sharply inhibited in rats during hypokinesia: follicular epithelium was flattened; the follicles were large and distended with dense, folded colloid, with no zones of resorption; in many cases their walls were ruptured. Adaptation to hypoxia (80 days) led to moderate hypofunction of the thyroid gland with no pathological changes in its parenchyma: small follicles with liquid colloid, numerous zones of resorption, follicular epithelial cells were high. Adaptation to hypoxia combined with hypokinesia reduced the pathological effect of the latter on thyroid function, although the types of response varied: in 1 subgroup there were small follicles with high thyroid epithelia, zones of resorption, and liquefaction of the colloid (changes were similar to group 3); in the other subgroup a marked decrease in height of the follicular epithelium was observed, nuclei were flattened and compressed, the follicles were large with dense colloid without zones of resorption, and the walls of the follicles were ruptured. Changes here were similar to group 2, although no hypertrophy of the connective tissue bands could be observed, and individual follicles were found with evidence of functional activity.

SOURCE: Bulletin of Experimental Biology and Medicine 81(6): 807-808, 1976

AUTHOR(S): Barlow, S.M., A.F. Knight, and F.M. Sullivan

EXPERIMENT TITLE: Delay in Postnatal Growth and Development of Offspring
Produced by Maternal Restraint Stress During Pregnancy
in the Rat

SUBJECTS: Female Porton-Wistar/Ola rats (185-240 gm)

AREA OF STUDY: Reproduction

OBJECTIVES: In title

PROTOCOL: Two experiments: 1) rats were stressed by taping to a board for 9 hr/day on 3 consecutive days during various stages of pregnancy. The growth, development and behavior of the offspring was then studied until they reached sexual maturity; 2) rats were stressed 9 hr/day on days 18-20 of pregnancy. After delivery, the offspring were either fostered onto mothers from the same treatment group or cross-fostered onto mothers from the opposite treatment group to that of their own biological mothers. The offspring were assessed by the following criteria: opening of ear flaps, eruption of lower incisors, appearance of auditory startle response, opening of eyelids and locomotor responses to various tests.

IMMOBILIZATION METHOD: Board

RESULTS: Restraint at any stage of pregnancy caused a significant decrease in offspring body weight persisting up to 6 wk of age, and delayed the appearance of certain developmental landmarks. Postnatal mortality and impairment of ability to orient to the home cage were significantly increased in the offspring from animals restrained on days 18-20 of pregnancy. The effects of restraint were most marked in prenatally stressed pups reared by stressed mothers and least marked in controls reared by controls, with the other two cross-fostered groups being intermediate.

SOURCE: Teratology 18(2): 211-218, 1978

AUTHOR(S): Bartlett, R.G. and U.D. Register

EXPERIMENT TITLE: Effect of Cold and Restraint on Blood and Liver
Non-Protein Sulfhydryl Compounds

SUBJECTS: Adult Sprague-Dawley rats, 21 males (250-300 gm) and
21 females (180-250 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls exposed at 22°C; 2) unrestricted exposed at 0°C; 3) restricted at 0°C. Restraint was produced by means of a loose fitting wire mesh cylinder. Control rats were housed in cages until sacrificed, while the latter 2 groups were placed, for periods varying between 2 and 4 hr, in a refrigerator set to maintain a temperature of 0°C ± 2°C. Measurements: ergothioneine (ESH), glutathione (GSH), total non-protein sulfhydryl (TSH).

IMMOBILIZATION METHOD: Wire mesh cylinder

RESULTS: No significant change in GSH or TSH concentration in the blood of rats was produced by restraint or cold. There was a slight drop in ESH. Similar treatment produced no change in ESH concentrations of the liver. There was a significant drop in GSH and TSH in the livers of the restricted animals, particularly in the females.

SOURCE: Proceedings of the Society for Experimental Biology and Medicine
83: 708-709, 1953

AUTHOR(S): Bartlett, R.G., Jr., V.C. Bohr, R.H. Helmendach, G.L. Foster, and M.A. Miller

EXPERIMENT TITLE: Evidence of an Emotional Factor in Hypothermia Produced by Restraint

SUBJECTS: Male Sprague-Dawley rats (250-450 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: To determine the degree to which temperature control was lost as a result of restraint

PROTOCOL: Three groups were placed in a cold room at $2^{\circ}\text{C} \pm 2^{\circ}$ for 2 hr while rectal body temperature was measured: 1) controls - 26 unrestrained rats; 2) experimental - 26 rats restrained in wire mesh cylinders; 3) dead, 40 unrestrained and restrained rats. Prior to restraint in hypothermic conditions the animals were studied in open field tests to determine the rate of defecation, then classified as more emotional and less emotional.

IMMOBILIZATION METHOD: Wire mesh cylinder

RESULTS: There was no demonstrable difference between the temperature drop of the caged or uncaged dead rats. The degree of hypothermia was correlated with the emotionality of the rats.

SOURCE: American Journal of Physiology 179: 343-346, 1954

AUTHOR(S): Bartlett, R.G., Jr., V.C. Bohr, and R.H. Helmendach

EXPERIMENT TITLE: Ability of Rat to Adapt to Stress of Light Restraint

SUBJECTS: 30 Young adult male Sprague-Dawley rats

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Body temperatures were compared during 3 periods of the experiment: 1) before adaptation; 2) after adaptation; and 3) one-week post-adaptation. Adaptation was achieved by placing the rats in restraining cages for 1 wk. Before and after adaptation the animals were tested in restraint cages up to 7 hr in a cold room. After the 2nd exposure, the rats were taken out of the restraining cages and maintained in the laboratory for 1 wk. They were then placed in the restraining cages in the cold room again for a 6-hr exposure. Diet: food and water ad libitum.

IMMOBILIZATION METHOD: Cage

RESULTS: Rats were able to adapt to restraint-imposed stress so that they did not become hypothermic when exposed to cold stress.

SOURCE: Proceedings of the Society for Experimental Biology and Medicine
86: 395-396, 1954

AUTHOR(S): Bartlett, R.G., Jr., R.H. Helmendach, and W.I. Inman

EXPERIMENT TITLE: Effect of Restraint on Temperature Regulation in the Cat

SUBJECTS: 40 Adult cats of both sexes

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 14 controls; 2) 13 restrained; and 3) 13 dead animals. The controls were housed individually in large cages in a cold room ($-15^{\circ}\text{C} \pm 2^{\circ}\text{C}$). Deep rectal temperatures were taken with a thermometer at the beginning and end of tests. Restraint was achieved in one of two manners. Some animals had their legs tied to 4 upright posts; others had their hind legs tied to pegs while their necks were placed between uprights. The restrained animals were placed in the cold room and body temperatures were taken with indwelling rectal thermometers inserted to a depth of 3-5 inches. The dead cats were placed in the cold room with indwelling rectal thermometers and temperatures taken intermittently throughout the experiment.

IMMOBILIZATION METHOD: Legs tied

RESULTS: Body temperatures of the restrained animals over a 2-hr exposure fell markedly (5.6°C) as compared to the control group (1.2°C). The temperature fall of the dead animals was the greatest (10.2°C).

SOURCE: Proceedings of the Society for Experimental Biology and Medicine
85: 81-83, 1954

AUTHOR(S): Bartlett, R.G., Jr.

EXPERIMENT TITLE: Stress Adaptation and Inhibition of Restraint-Induced (Emotional) Hypothermia

SUBJECTS: 88 Adult male albino rats (175-275 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Experiment 1 - Restraint/Cold Stress; 4 groups of 12 rats were exposed to light restraint and cold ($4-8^{\circ}\text{C}$) for 3 hr: 1) each day; 2) every 2nd day; 3) every 4th day; and 4) every 8th day. Restraint was produced by maintenance in a loosely fitting wire mesh cylinder. Thermometers were inserted in the rectum for recording temperatures. Experiment 2 - Forced Muscular Exercise; 2 groups of 20 rats: 1) exercised (forced muscular) daily; and 2) controls. After 12 days of exercise (3-10 min/day), all 40 rats were placed in restraining cages in the cold room ($5^{\circ}\text{C} \pm 2^{\circ}\text{C}$) for 3 hr. Body temperature changes were noted.

IMMOBILIZATION METHOD: Wire mesh cylinder; Cage

RESULTS: Experiment 1: Rats adapted to the dual stress of cold and restraint. There was a highly significant ($p < .01$) improvement in thermostability after the first 2 exposures in groups 1, 2 and 3. Daily exposure resulted in a high mortality rate. After just 1 or 2 exposures to dual stress, there was a marked inhibition of the hypothermic process when exposures were not more than 4 days apart. For group 4 there was no demonstrable improvement on the 2nd or 3rd exposures. Experiment 2: Daily exercise produced a degree of inhibition to restraint hypothermia.

SOURCE: Journal of Applied Physiology 8: 661-663, 1956

AUTHOR(S): Bartlett, R.G., Jr. and M.A. Miller

EXPERIMENT TITLE: The Adrenal Cortex in Restraint Hypothermia and in Adaptation to the Stress of Restraint

SUBJECTS: 196 Male and female Sprague-Dawley rats (180-340 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Three Series: I - Rats were restrained in a wire mesh cylinder for 4 hr at 0°C; exposed to 0°C for 4 hr without restraint; restrained for 4 hr at room temperature; adapted for 1 wk to the stress of restraint; or left untreated (controls). II - Adrenalectomized, received 1 mg desoxycorticosterone acetate (DCA) and 1 mg cortisone daily for 10 days after surgery then administered 1 mg DCA and 1 mg cortisone daily or 1 mg DCA or 1 mg cortisone, or isotonic salt solution daily. Sham adrenalectomized, received isotonic saline sc. All adrenalectomized rats were adapted to restraint for 1 wk at room temperature, then all groups were restrained for 4 hr at 0°C. III - Intact rats received 2 mg cortisone or saline daily for 1 wk then restrained at 0°C. Measurements: rectal temperature; cholesterol and ascorbic acid in homogenized adrenals.

IMMOBILIZATION METHOD: Wire mesh cylinder

RESULTS: Rats adapted to the stress of restraint had increased levels of adrenal ascorbic acid and cholesterol; nonadapted animals exposed to either restraint or cold showed decreased levels of cholesterol and ascorbic acid. In animals in which both stresses were applied simultaneously, levels of adrenal cholesterol and ascorbic acid were not significantly lower than when only 1 stress was applied. Rats adapted to stress, whether intact or adrenalectomized and treated with cortisone and DCA or cortisone only, were capable of maintaining body temperature when subjected to cold restraint. Intact rats adapted to stress, experienced a gradual body temperature decrease, as did those that were adrenalectomized and treated with DCA only. Intact rats given 2 mg cortisone daily, but not adapted to stress, were able to maintain body temperature better than those not receiving cortisone under the same conditions, but did not maintain body temperature as well as those adapted to stress.

SOURCE: Journal of Endocrinology 14: 181-187, 1956

AUTHOR(S): Bartlett, R.G., Jr. and F.H. Quimby

EXPERIMENT TITLE: Heat Balance in Restraint (Emotionally) Induced Hypothermia

SUBJECTS: 48 Male (225-275 gm), 20 female (225-275 gm) Sprague-Dawley rats

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two experiments: I - 3 groups: 1) restrained in a loose fitting wire mesh cylinder flattened on the underside and closed at both ends, rat in an abnormally elongated position with thinly furred underparts exposed; 2) restrained in wire mesh cylinder formed to allow the rat to assume a "normal cold posture" with the ventral fore and hind regions forced into apposition; 3) controls. Groups were restrained for 3 hr at $5 \pm 2^{\circ}\text{C}$. Experiment II - 2 groups: 1) restrained in wire mesh cylinders; 2) controls. Both groups were maintained at $5 \pm 2^{\circ}\text{C}$. Measurements: Experiment I - initial and terminal colonic temperature; Experiment II - body temperature and surface temperature using a Hardy dermal radiometer.

IMMOBILIZATION METHOD: Wire mesh cylinder

RESULTS: Experiment I - Reduction of the effective body surface exposure resulted in a significantly lower rate of fall of the body temperature of the restrained rats. Terminal colonic temperatures were 21.7°C for the greater body exposure group, 27°C for the rats in a huddled position and 37.9°C for the controls. Experiment II - There was a significantly greater rate of heat loss per unit area of body surface in restrained rats, accompanied by a grossly obvious lesser degree of piloerection.

SOURCE: American Journal of Physiology 193: 557-559, 1958

AUTHOR(S): Bartlett, R.G., Jr. and P.D. Altland

EXPERIMENT TITLE: Effect of Restraint on Altitude Tolerance in the Rat

SUBJECTS: 36 Male (241-309 gm), 36 female (164-263 gm), young adult Sprague Dawley rats

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) nonrestrained controls; 2) restrained in loose fitting wire mesh cylinders, flattened on the underside and closed at both ends. Both groups were subjected to a simulation of slowly increasing altitude up to 33,500 ft at 2000 ft/min. Tests were usually terminated after 6 hr. Measurements: time of death as judged by last visible respiratory movement; colonic temperatures of surviving animals.

IMMOBILIZATION METHOD: Wire mesh cylinder

RESULTS: Restrained rats died significantly sooner than unrestrained rats; only 3 of the 36 restrained rats and 9 of the 36 unrestrained rats survived the 6 hr exposure. Survivors, when resubjected to a 2nd altitude test, all survived the 2nd 6 hr exposure. There was a significant difference in the average terminal colonic temperatures after 2 exposures; $25 \pm .4^{\circ}\text{C}$ for the restrained rats and $31.3 \pm .4^{\circ}\text{C}$ for the controls.

SOURCE: Journal of Applied Physiology 14: 395-396, 1959

AUTHOR(S): Bartlett, R.G., Jr. and P.D. Altland

EXPERIMENT TITLE: Relation of Body Temperature and Restraint to Altitude Tolerance in the Rat

SUBJECTS: 252 Male and female Sprague Dawley rats (150-300 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) nonrestrained; 2) restrained in a loosely fitting wire mesh cylinder, flattened on the underside and closed at both ends. Rats from both groups were placed in a decompression chamber to simulate an altitude of 33,500 ft at various rates of ascent. Variations in pre-altitude exposure were tested. Measurements: altitude tolerance by death of rat; colonic temperature.

IMMOBILIZATION METHOD: Wire mesh cylinder

RESULTS: Rats restrained immediately before altitude exposure with rapid ascent (2000 ft/min) to altitude (33,500 ft) died significantly sooner than controls. Slow stepwise ascent to altitude (2½-4 hr) increased the altitude tolerance, particularly for restrained animals. When body temperatures were dropped to 25°C before altitude exposure, there were no deaths for up to 6 hr in either group. A lesser temperature fall provided less protection. Female control rats demonstrated greater altitude tolerance compared to male controls.

SOURCE: Journal of Applied Physiology 14: 785-788, 1959

AUTHOR(S): Baybara, V.S.

EXPERIMENT TITLE: Morphological Changes in Bronchial Vessels Associated With Experimental Hypodynamia and Hypokinesia

SUBJECTS: 30 Rabbits

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Experimental rabbits were kept in small individual boxes for 2-14 wk to create hypokinesia. Thirty rabbits were used: 6 sacrificed after 2 wk, 8 after 4 wk, 6 after 8 wk, and 5 after 12-14 wk, 5 controls. Following decapitation, the bronchi were fixed in 12% neutral formalin for 3-7 days.

IMMOBILIZATION METHOD: Box (small individual)

RESULTS: After 2 wk of hypokinesia there was a tendency toward increased filling of vessels. After 4 wk there were marked dynamic changes in the vessels. Precapillaries, capillaries, postcapillaries and venules were entirely filled with formed blood elements and became tortuous. There was a sharp disproportion between the caliber of arteriolar and venular caliber. Fine and large hemorrhages were seen along the venules and capillaries; there were breaks in the vascular walls. At 8 wk, some stabilization in the structure of blood vessels of the bronchial wall was observed. After 12-14 wk of hypodynamia and hypokinesia there were degenerative changes in intraorganic vessels of the bronchi especially in the capillary region.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii No.11: 95-99, 1971

AUTHOR(S): Bayev, K.V.

EXPERIMENT TITLE: Rhythmic Discharges in the Motor Hindlimb Nerves of Decerebrate Immobilized Cats Induced by Intravenous Injection of Dopa

SUBJECTS: Cats

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: The cats were immobilized with tubocurarine and decerebrated at the precollicular level. Spontaneous discharges were measured in the motor nerves innervating the m. posterior biceps and the m. gastrocnemius medialis. Dopa (100 mg/kg) in conjunction with the MAO inhibitor iprazidum (50 mg/kg) was then injected intravenously and the discharges in the motor nerves recorded.

IMMOBILIZATION METHOD: Drug

RESULTS: Before administration of dopa + iprazidum the nerves were not spontaneously active. Administration of dopa together with iprazidum was capable of effectively activating the spinal cord mechanism for the direction of locomotion and the development of this activity passes through several temporal phases that bear a definite resemblance to various forms of real locomotion. The duration of rhythmicity from the beginning to complete disappearance was 2-3 hr.

SOURCE: Neirofiziologiya 9(2): 210-212, 1977

AUTHOR(S): Bayev, K.V.

EXPERIMENT TITLE: Spontaneous Rhythmic Discharges in Motor Hindlimb
Nerves of Decerebrated Immobilized Cats

SUBJECTS: 28 Cats

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: The cats were decerebrated at various levels and spinalized under ether anesthesia. Discharges were measured from nerves innervating the following muscles of the hindlimbs: m. semitendinosus, m. semimembranosus, m. extensor digitorum longus, m. flexor digitorum longus and m. gastrocnemius medialis. Nerves prepared for stimulation were the m. peroneus communis, m. tibialis and m. suralis. The animals were immobilized with tubocurarine.

IMMOBILIZATION METHOD: Drug

RESULTS: Spontaneous fictitious locomotion regularly appeared only in animals decerebrated at level A-13 or higher. Prolonged stimulation of the "locomotor hypothalamic region" produced the appearance of rhythmic discharges in the motor nerves. During supplementary decerebration or spinalization there were also rhythmic discharges that were curtailed some dozens of seconds following transsection. It appeared that an activating effect on the spinal locomotor centers was exercised by the hypothalamic nerve formations through the underlying structures of the brain stem. In the absence of the caudal portion of the hypothalamus these structures were incapable of activating the spinal locomotor centers to the extent required for the appearance of spontaneous rhythmic discharges in the motor nerves.

SOURCE: Neirofiziologiya 9(6): 622-625, 1977

AUTHOR(S): Beattie, D.

EXPERIMENT TITLE: Physiological Changes in Rats Exposed to Cold/Restraint Stress

SUBJECTS: Male Charles River rats (80-100 gm)

AREA OF STUDY: Blood; Digestive; Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control animals were fasted overnight and dosed orally with 0.3% carboxymethylcellulose and remained unrestrained during the experimental period; 2) experimental group immobilized in open wire restraint cages for 3 hr in a cold room at $4^{\circ}\text{C} \pm 1^{\circ}\text{C}$. After the 3 hr stress period the stomachs of each group of rats were examined to confirm the presence of gastric erosions. Renal function was studied via urinalysis for electrolyte and urea content. Plasma constituent analysis was carried out on blood samples taken from the vena cava to determine levels of electrolytes, plasma glucose, urea, and serum creatinine. Hematology studies included measurements of hemoglobin, hematocrit, RBC count, WBC count, platelet count, and differential white cell count. The pH of the blood was measured as well as serum thyroxine and insulin levels.

IMMOBILIZATION METHOD: Cage (aluminum open wire)

RESULTS: Cold/restraint caused an increased volume of urine with increased potassium and urea excretion, and decreased sodium and chloride excretion. There was a fall in plasma glucose and a rise in plasma urea. A marked leucopenia was found and the blood pH was significantly lowered. Cold/restraint was also found to cause marked increases in corticosterone and thyroxine levels and a fall in the insulin level.

SOURCE: Life Sciences 23: 2307-2313, 1978

AUTHOR(S): Bekishev, K.

EXPERIMENT TITLE: Effect of Sharply Lowered Muscular Activity on the Thyroid Gland of the White Rat

SUBJECTS: 200 White rats (170-190 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats were placed in small cages from 1 to 90 days (10 rats were selected for each time period). Measurements: body weight; calf muscle weight; height of the follicular epithelium; interior diameter of the follicles; condition of colloid.

IMMOBILIZATION METHOD: Cage (16 x 6 x 6 cm)

RESULTS: The functional activity of the thyroids increased after 24 hr of partial immobilization and peaked after 15 days. After 30 days of immobilization, the functional activity returned to normal in one third of the test animals and after 60 days in all animals. After 15 days of immobilization, the test animals began to lose weight (in comparison to the controls) and remained underweight for the rest of the test period (up to 90 days). When returned to normal conditions, they caught up with and even overtook in weight the control animals after about 1 mo. All changes produced by hypokinesia were reversible after 1 mo.

SOURCE: Izvestiia Akademii Nauk SSSR. Serii Biologicheskaya No.2: 75-78, 1978

AUTHOR(S): Belak, M., J. Kocisova, and K. Bod'a

EXPERIMENT TITLE: Ultrastructural Studies of the Mitochondriae in the Striated Muscles of Birds With Regard to Experimental Hypokinesia

SUBJECTS: 354 Japanese quail, 77 days old

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinesia in cages for 6 hr per day for 100 days. Excisions of muscle tissue were then taken from the pectoralis thoracicus and from the iliotibialis posterior, which were breast and thigh muscles, respectively. Muscle samples were prepared for the electron microscope, and then photographed. Measurements: degree of changes in mitochondrial ultrastructure.

IMMOBILIZATION METHOD: Cage

RESULTS: The myofibrils of the muscles of the control animals formed repeating uniform sarcomeres. Both filamentous mitochondria of the breast muscles and ovoid mitochondria of the thigh muscles showed the same changes. Vacuoles were observed which in some cases produced larger light formations with the following disappearance of the cristae and destruction of the mitochondria. Fat particles located at the poles of the altered mitochondria showed that the Z-lines of the sarcomere did not form a continuous line, but were somewhat shifted.

SOURCE: Archiv fuer Experimentelle Veterinaermedizin 31(4): 537-546, 1977

AUTHOR(S): Belkanija, G.S. and S.Kh. Tatojan

EXPERIMENT TITLE: Pulsimetric Analysis of the Heart Rhythm of Restrained and Unrestrained Rhesus Macaques

SUBJECTS: Adult rhesus monkeys (4-7 kg)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Three groups: 1) nonrestrained controls; 2) restrained with the monkey facing downwards, resting on its hands; 3) restrained on back, tied to a tilt table. The pulsometric indices of the cardiac rhythm in the horizontal, head-up and head-down positions were determined by EKGs, in the control group by telemetric methods. Measurements: comparison of R-R intervals, autocorrelation analysis of EKG.

IMMOBILIZATION METHOD: Tied down

RESULTS: Acceleration of the heart rhythm was noted in all experiments in the transition of animals to orthostatic head-up position, along with a decrease of the mean duration of R-R interval. There were extremely pronounced changes in the heart rhythm of both free and restrained monkeys from the morning (8-10 AM) to the maximum resting period (2 PM). The state of sympathetic and parasympathetic activity was differentiated according to body position change and immobilization by pulsometric analysis.

SOURCE: Zeitschrift fur Versuchstierkunde 18: 62-77, 1976

AUTHOR(S): Berendt, R.F.

EXPERIMENT TITLE: The Effect of Physical and Chemical Restraint on
Selected Respiratory Parameters of Macaca mulatta

SUBJECTS: 20 Rhesus monkeys (1-2 kg)

AREA OF STUDY: Respiratory; Pharmacology

OBJECTIVES: In title

PROTOCOL: The animals were fasted on the day of the experiment. Two groups: 1) physically restrained; 2) drug injected (intramuscular injection of 1 ml/kg of phencyclidine hydrochloride). Readings were taken 10, 20 and 30 min after treatment. The effect of each treatment was determined on each of 20 animals in each of 3 experiments. Measurements: respiration rate; minute volume; heart rate; tidal volume.

IMMOBILIZATION METHOD: Strait jacket

RESULTS: Restraint of the animals with a strait jacket produced an initial rise in minute volume, respiration, and heart rates. This rise was followed by a decline, but the magnitude was not as great as that seen in the animals prior to treatment. The minute volume of the strait-jacketed animals was about 3 times that of drug-treated animals. The 2 treatments also produced significantly different respiration rates (drug-treated about 67% of the strait-jacketed animals), heart rates (drug-treated rate about 84% of the jacketed animals), and tidal volumes (drug-treated about 52% of the jacketed animals).

SOURCE: Laboratory Animal Care 18(3): 391-394, 1968

AUTHOR(S): Berendt, R.F. and T.D. Williams

EXPERIMENT TITLE: The Effect of Restraint and Position Upon Selected Respiratory Parameters of Two Species of Macaca

SUBJECTS: Rhesus (Macaca mulatta) and cynomolgus (Macaca fascicularis) monkeys

AREA OF STUDY: Respiratory

OBJECTIVES: In title

PROTOCOL: All monkeys were held in quarantine for at least 12 wk before use. On test days, the monkeys were not fed prior to use. Experiments: 1) effect of position on Macaca mulatta, 18 animals subjected to both supine and seated positions for 1, 5, 10, 20, 30, 40 and 50 min; 2) effect of position on Macaca fascicularis, 24 animals in the same manner as experiment 1; 3) effect of restraint, 20 animals restrained for 20 min on the V-board either in a supine position or held erect, or in a plastic chair while seated or tilted in a supine position. Measurements: respiration; tidal volume; minute volume.

IMMOBILIZATION METHOD: Plastic chair; V-board

RESULTS: The method of restraint rather than position had a more pronounced effect on both species. Plastic chair restraint caused high tidal volumes and low respiration rates; results were the opposite for V-board restraint. Resting time caused a marked diminution of all parameters except the respiration of monkeys strapped to the V-board.

SOURCE: Laboratory Animal Science 21(4): 502-509, 1971

AUTHOR(S): Bert, J. and H. Collomb

EXPERIMENT TITLE: Effect of Immobilization on the EEG of the Baboon.
Comparison With Telemetry Results From Unrestricted
Animals

SUBJECTS: Baboons (Papio papio)

AREA OF STUDY: Nervous; Behavior

OBJECTIVES: In title

PROTOCOL: Two groups: 1) immobilized in chair, 37 baboons; 2) unrestricted movement, 12 baboons. Measurements: EEG - 4 channel recordings of ocular movement, fronto-central, parieto-occipital, and myogram of neck muscles.

IMMOBILIZATION METHOD: Chair

RESULTS: Immobilized, 3 stages were described: 1) activation, record desynchronized; 2) rest with 13-15 cm/sec rhythm, like the human alpha rhythm stage but with eyes open or closed; 3) "relaxation" with a decrease in 13-15 rhythm and the appearance of 5-7 cm/sec theta waves, eyelids closed, animal apparently sleeping. In free animals the rest stage appeared when the animal's attention was not directed anywhere and there was no "relaxation" stage. There was an exact and constant sequence taking the animal from the rest stage with eyes closed to sleep. The "relaxation" stage succeeded the rest stage without an intermediary stage of fundamental rhythm reinforcement. In the "relaxation" stage the theta waves were more abundant and occurred in bursts more so than in sleep. This stage may be compared with states of so-called animal hypnosis; a special functional state to be clearly distinguished from the physiological stages of sleep.

SOURCE: Comptes Rendus des Seances de la Societe de Biologie et de ses
Filiales 159(5): 1202-1204, 1965

AUTHOR(S): Besch, E.L., A.H. Smith, R.R. Burton, and S.J. Sluka

EXPERIMENT TITLE: Physiological Limitations of Animal Restraint

SUBJECTS: Mature Single Comb White Leghorn, commercial hybrid fowl

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: Four groups: 1) restraint in "Bird Box" made of rigid concave styrofoam blocks, with wings free and legs immobilized with webbed straps; 2) restraint in harness-sling, and suspended in the harness (some birds in this group were given reserpine during restraint); 3) restraint in harness-cage, where the body of the bird was supported by the legs and feet, but motion was restricted; 4) non-restrained animals deprived of food. Restraint totalled 10 days over an alternating schedule for 20 days. Diet: reserpine mixed with feed (150 ppm) fed ad libitum for 10 days prior to restraint, then normal feed and water ad libitum. Measurements: differential and total white blood cell counts; weight; plasma calcium; hematocrit and plasma protein.

IMMOBILIZATION METHOD: Box; Harness (suspended)

RESULTS: The effect of restraint was directly proportional to the duration of the restraint. The effects were similar to starvation syndrome and generalized dehydration. Animals that were free but deprived of food and water survived for a significantly longer time than restrained animals, although their weight loss was much greater. The effects of restraint on white blood cells was similar to that following injection of ACTH and cortisone-acetate. There was a relative and absolute lymphopenia and rise in heterophils with no change in the absolute numbers of erythrocytes.

SOURCE: Aerospace Medicine 38: 1130-1134, 1967

AUTHOR(S): Besch, E.L., R.R. Burton, and A.H. Smith

EXPERIMENT TITLE: Organ and Body Mass Changes in Restrained and Fasted Domestic Fowl

SUBJECTS: Adult male single comb white leghorn fowl

AREA OF STUDY: Body mass

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls; 2) restrained in a harness-cage - the animal was placed in a body harness with its body supported by the feet and legs, movement within the cage was restricted by securing the harness to the sides; 3) fasted. All birds were weighed following testing for 9 days, and then sacrificed by cervical luxation. Measurements: organ weight; body mass.

IMMOBILIZATION METHOD: Harness-cage

RESULTS: Body mass loss changes in restrained birds were 63% ($p < .001$) greater than in the fasted group, but both groups recovered at the same rate. Restrained birds showed increased heart, lung, kidney, liver, and adrenal size, but greater loss of spleen, superficial pectoral muscle, small intestine and pancreas masses. Relative water content of organs generally increased in restrained and decreased in fasted birds.

SOURCE: Proceedings of the Society for Experimental Biology and Medicine 141(2): 456-459, 1972

AUTHOR(S): Bezdrobnyy, Yu.V.

EXPERIMENT TITLE: Biosynthesis of ACTH and Somatotrophic Hormones in the Hypophysis of Rats Following Prednisolone Block, Immobilization and Starvation

SUBJECTS: Rats (200-250 gm)

AREA OF STUDY: Endocrine; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Five groups: 1) controls for the following groups; 2) received prednisolone 18 mg sc every other day for 6 days; 3) immobilized for 60 min by securing to a bench in a supine position, methionine-S³⁵ administered to 2 groups of 5 rats; 4) starvation - water only for 5 days, administered glycine-1-C¹⁴; 5) adrenalectomized rats administered methionine-S³⁵. At the termination of the experiment the incorporation of the radioactive amino acids into ACTH and STH in the hypophyses was measured.

IMMOBILIZATION METHOD: Tying to a bench

RESULTS: The incorporation of methionine-S³⁵ into ACTH of hypophyses taken from animals that had received prednisolone showed no variations from normal values. Immobilization did not change the incorporation of methionine-S³⁵ into ACTH. Five days fasting did not induce changes in the level at which glycine-1-C¹⁴ was incorporated into STH in the hypophysis. Incorporation of methionine-S³⁵ into STH with hypophyses obtained from animals given prednisolone was also normal. The incorporation of labelled amino acids into ACTH and STH differed from normal values only in the adrenalectomized rats.

SOURCE: Problemy Endokrinologii 15(2): 74-77, 1969

AUTHOR(S): Bhattacharya, S.K., P.R. Keshary, and A.K. Sanyal

EXPERIMENT TITLE: Immobilisation Stress-Induced Antinociception in Rats: Possible Role of Serotonin and Prostaglandins

SUBJECTS: Albino Wistar rats (100-150 gm)

AREA OF STUDY: Nervous; Pharmacology

OBJECTIVES: In title

PROTOCOL: Rats were deprived of food for 18 hr before and water immediately before immobilization. The animals were immobilized by tying and taping the fore and hind limbs separately and then together; they were placed inside individual restraint chambers and the tail was taped. The experiments were conducted at ambient temperature of $25 \pm 1^\circ\text{C}$. Eight groups: 1) unrestrained control; 2) immobilization for 1 hr; 3) immobilization for 2 hr; 4) immobilization for 4 hr; 5) administration of p-chlorophenylalanine methyl ester hydrochloride (100 mg/kg ip once daily for 3 days, the last injection being given 24 hr before experiment) and immobilization for 4 hr; 6) administration of 5,6-dihydroxytryptamine creatinine phosphate (75 μg iv) 48 hr prior to immobilization for 4 hr; 7) administration of diclofenac sodium (10 mg/kg ip) 4 hr prior to immobilization for 4 hr; and 8) administration of indomethacin (15 mg/kg ip) 4 hr prior to immobilization for 4 hr. Measurements: antinociceptive activity.

IMMOBILIZATION METHOD: Chamber and tape

RESULTS: Immobilization for 1, 2 and 4 hr produced duration-related increasing antinociception. The antinociception induced by 4 hr immobilization was significantly inhibited with p-chlorophenylalanine, 5,6-dihydroxytryptamine, diclofenac or indomethacin, to the extent of 67.7%, 84.9%, 74.7% and 63.6%, respectively.

SOURCE: European Journal of Pharmacology 50(1): 83-85, 1978

AUTHOR(S): Bialowas, J., M. Jurkowski, M. Stachowiak, and A. Dytkowska

EXPERIMENT TITLE: The Influence of Food Deprivation, Exposure to Cold and Immobilization on Monoamine Oxidase Activity in Some Hypothalamic Nuclei of the Rat Brain

SUBJECTS: Male Wistar albino rats (210-310 gm)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Three experimental groups: 1) food deprived rats were starved for 48 hr; 2) animals exposed to cold were kept at a temperature of -8°C for 3 hr; 3) animals were immobilized for one hour. Each of the three experiments were performed in the summer, spring, and winter and separate control animals of similar weight and colonies were used. After the experimental period the animals were decapitated, brains removed and sectioned in the frontal plane. Particular nuclei were removed from 600 μ m sections. Monoamine oxidase (MAO) activity was determined using ³H-tryptamine as a substrate in samples containing bilaterally removed nuclei collected from two rats. Protein concentration was determined.

IMMOBILIZATION METHOD: Not stated

RESULTS: In food deprived rats, slight or no enhancement of MAO activity was found. In rats exposed to cold, MAO activity was reduced to 67-75% of control values in the septum and arcuate nucleus. In immobilized animals a statistically significant decrease of enzyme activity was found in the arcuate nucleus.

SOURCE: Acta Neurobiologiae Experimentalis 38: 283-288, 1978

AUTHOR(S): Blaszkowski, T.P., J.J. DeFeo, and A.M. Guarino

EXPERIMENT TITLE: Central vs. Peripheral Catecholamines in Rats During Adaptation to Chronic Restraint Stress

SUBJECTS: Male Sprague-Dawley albino rats (75-100 gm)

AREA OF STUDY: Endocrine; Pharmacology

OBJECTIVES: In title

PROTOCOL: Preliminary dose response study: 12 groups of 10 animals each. Each day for 6 days, groups received in mg/kg, ip injection of: reserpine, vehicle, 0.05. 0.1. 0.25, 1.0 and 2.5; guanethidine, vehicle, 0.5, 1.0. 2.5, 5.0 and 10.0. The brains and heart were removed 8 hr after the last injection. Measurements ED_{50} (50% depletion of norepinephrine for the brain and heart effects of reserpine and guanethidine). A total of 300 animals were used for chronic restraint stress studies for 1, 3, 6, 12 or 24 days. The daily treatment for each group was as follows: 1) vehicle control, received the drug vehicle daily ip; 2) guanethidine control, received guanethidine 1.2 mg/kg ip; 3) reserpine control, received reserpine 0.2 mg/kg ip; 4) vehicle restrained, received drug vehicle and restrained daily; 5) guanethidine 1.2 mg/kg restrained; 6) reserpine 0.2 mg/kg restrained. Restraint consisted of being immobilized in the supine position on a restraint board for 5 hr. Controls were kept unrestrained in metabolism cages. After experimentation the restrained and control groups were decapitated. The blood and adrenals were stored for assay and the brain frozen. Measurements: the whole brain, adrenal, and heart norepinephrine was estimated fluourometrically; serum corticosterone, adrenal ascorbic acid. The diet consisted of Purina rat chow.

IMMOBILIZATION METHOD: Board

RESULTS: Reserpine-stressed animals showed 40% mortality over the 24 day period. Guanethidine-stressed animals showed 10% mortality while stressed control animals showed no mortality over the same time period. The mortality in the reserpine-stressed group was not due to starvation or decreased water uptake, but appeared to be associated more with central brain rather than peripheral heart depletion of norepinephrine.

SOURCE: Pharmacology 4: 321-333, 1970

AUTHOR(S): Blum, J.E. and A. Huerlimann

EXPERIMENT TITLE: Effect of Psychotropic Drugs on Gastric Ulcers Induced By Immobilization. Increased Protective Effect of Amitriptyline Caused By Chlordiazepoxide

SUBJECTS: Male albino rats, Fuellinsdorf breed (60-70 gm)

AREA OF STUDY: Digestive; Pharmacology

OBJECTIVES: In title

PROTOCOL: Groups of 10, fasted for 48 hr, then immobilized by superficial ether anesthesia for 16 hr: 1) amitriptyline hydrochloride treated; 2) chlordiazepoxide hydrochloride treated; 3) both drugs; 4) controls. Various dosage levels were administered sc 30 min prior to immobilization. Measurement: gastric erosions.

IMMOBILIZATION METHOD: Ether anesthesia

RESULTS: All animals not treated presented a number of erosions. Chlordiazepoxide had no effect even in large doses. The protective effect of amitriptyline depended upon the dosage. When it was given simultaneously with chlordiazepoxide the protective effect was greater than for amitriptyline alone.

SOURCE: Medicina et Pharmacologia Experimentalis 15(6): 615-617, 1966

AUTHOR(S): Bogina, I.D., N.A. Rokotova, Ye.S. Rogovenko, and R.L. Sheykin

EXPERIMENT TITLE: Effect of Partial Restraint of Motor Activities on
Basic Physiological Processes in Monkeys

SUBJECTS: 3 Monkeys (2 capuchins, 1 macaque)

AREA OF STUDY: Respiration; Nervous; Circulatory

OBJECTIVES: In title

PROTOCOL: Restraint: 1, 2, 3 and 15 days. Each animal was held by a belt and collar, both fastened to vertical bars clamped on a common base. A seat (for macaque) or a footstool (for capuchins) was fastened to the bars. Measurements: circadian respiratory rhythm; cardiac activity; brain bioelectric activity; motor activity.

IMMOBILIZATION METHOD: Belt, collar, and either seat or footstool

RESULTS: Under conditions of partial restraint the respiration, heart beat, and bioelectric brain activity of the monkeys remained within normal limits.

SOURCE: Problems of Space Biology 4: 294-300, 1965

AUTHOR(S): Bonfils, S., G. Rossi, G. Liefoghe, and A. Lambling

EXPERIMENT TITLE: Experimental Restraint Ulcer in the White Rat. I.
Methods, Incidence of Lesions, and Modifications by
Certain Technical and Pharmacodynamic Techniques

SUBJECTS: Female Wistar rats (150-190 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Seven groups: 1) controls, non-immobilized; 2) immobilized in wire mesh and suspended for 7 or 24 hr, intact; 3) adrenalectomized, 7 hr restraint; 4) cortisone injection daily for 3 or 7 days prior to 7 hr restraint; 5) Δ -1-cortisone injected daily for 3 or 7 days prior to restraint for 7 hr; 6) bilateral nephrectomy prior to 7 hr restraint; 7) vagotomy prior to 24 hr restraint. The rats were immobilized by wrapping them in wire mesh with their legs protruding and front and back legs tied together, then suspended in a burette holder. All animals were injected at onset of immobilization with 2.5 cc physiological saline into both rear legs. Animals were killed after the experiment, stomachs excised and examined. Measurements: incidence of ulcers in animals, number of ulcers per animal, degree of lesion.

IMMOBILIZATION METHOD: Wire mesh and a burette holder

RESULTS: Seven hr restraint produced an ulcer incidence of 58.9%; 24 hr restraint produced a 86.1% ulceration incidence. Adrenalectomy produced 67% ulcer incidence. Cortisone produced 41% ulcer incidence after 3 days administration, and 34.5% after 7 days, having the overall effect of reducing frequency of ulcers. Δ -1-cortisone, however, increased the frequency of ulcers. Nephrectomy produced fewer ventricular lesions. Vagotomy significantly decreased the frequency of gastric lesions.

SOURCE: Revue Francaise d'Etudes Cliniques et Biologiques 4: 146-150, 1959

AUTHOR(S): Bonfils, S., C. Richir, F. Potet, G. Liefvooghe, and A. Lambling

EXPERIMENT TITLE: Experimental Ulcers Induced By Forced Immobilization in the White Rat. II. Anatomopathology of the Gastric Lesions

SUBJECTS: White rats

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Seven groups: 1) control rats; 2) intact rats, immobilized for 7 or 24 hr in wire mesh with their legs protruding and front and back legs tied together, then suspended in a burette holder; 3) nephrectomy prior to 7 hr restraint; 4) cortisone injected prior to 7 hr restraint; 5) vagotomy prior to restraint; 6) suprarenalectomy prior to restraint; 7) freed after 24 hr restraint, sacrificed 1-9 days later. Animals were killed after the experiment and the stomachs, livers and kidneys excised and examined macro- and microscopically. Measurements: number and location of gastric lesions; healing process of lesions; extra-gastric visceral lesions.

IMMOBILIZATION METHOD: Wire mesh and burette holder

RESULTS: A single punctiform ulcer was found to be as significant as multiple ulcerations. Prolongation of the immobilization period was the determining factor of ulcer expansion and multiplication. For series with comparable immobilization periods, the number of lesions was primarily a function of the susceptibility of the individual animal. The immobilization caused ulcer was found only in the glandular area of the stomach. Nine days after release from immobilization, all lesions were healing or healed.

SOURCE: Revue Francaise d'Etudes Cliniques et Biologiques 4: 888-894, 1959

AUTHOR(S): Bonfils, S., G. Liefvooghe, X. Gelle, M. Dubrasquet, A. Lambling, and N. Enjoly

EXPERIMENT TITLE: Experimental "Restraint Ulcer" in the White Rat. III. Study and Analysis of the Part Played By Certain Psychological Factors

SUBJECTS: Female white rats (140-190 gm)

AREA OF STUDY: Digestive; Behavior

OBJECTIVES: In title

PROTOCOL: Three series: I - groups: 1) hypokinesia, suspended in "corset" for 7 or 24 hr; 2) hypokinesia for 7 or 24 hr after previous adrenalectomy, nephrectomy or corticotherapy; II - groups: 1) alternating 24 hr restraint and 48 hr release for 1 to 4 periods of restraint before being sacrificed; 2) controls, 3-24 hr fasts alternated with 48 hr of normal feeding, in the 4th period the rats were restrained; III - groups, intact and vagotomized rats were fasted and placed for 24 hr in 1 of 5 size cages: 1) 7350 cc (free movement); 2) 1260 cc (7 x 23 x 7.8 cm), rat can turn easily; 3) 750 cc (5 x 21 x 7.3 cm) some movement; 4) 560 cc (7 cm wide x size of rat); 5) 360 cc (4.5 cm wide x size of rat). The spaces were limited by glass rods threaded through holes in the chicken-wire cages and movable partitions. Measurements: number and degree of ulcers in stomach; behavior during restraint, weight.

IMMOBILIZATION METHOD: Series I: corset and suspended; Series II - not stated; Series III - cage, 5 decreasing volumes, 7350 cc; 1260 cc (7 x 23 x 7.8 cm); 750 cc (5 x 21 x 7.3 cm); 560 cc (7 cm x length and height of rat) and 360 cc (4.5 cm x length and height of rat).

RESULTS: Series I - Behavior during restraint was a succession of 3 stages - 1) continuous uncontrolled agitation for 15-45 min; 2) intermittent paroxysmal agitation for the rest of 24 hr restraint and 3) prolonged inertia, occurred in 50% of rats in restraints of 24 hr duration. There was no correlation between the 3 motor phases and the incidence of ulcers, mortality or weight loss. Series II - The frequency of acute ulcers diminished significantly with repeated restraint. Some rats were unaffected by restraint (15.2%) after 2 restraints; rhythmic fasts before a single restraint provided no protection from ulcers. Series III - There was a regular and significant increase in ulcer frequency with reduction of cage volume in both intact and vagotomized rats. Analysis of the 2 regression lines demonstrated that the more intense the restraint stimulus, the more effective the vagotomy.

SOURCE: Revue Francaise d'Etudes Cliniques et Biologiques 5: 571-581, 1960

AUTHOR(S): Booth, F.W. and C.L. Giannetta

EXPERIMENT TITLE: Effect of Hindlimb Immobilization upon Skeleton
Muscle Calcium in Rat

SUBJECTS: Male Sprague-Dawley rats (75-90 days old)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats, plaster of Paris casts applied to both hindlimbs so that ankle, knee, and hip joints were immobilized. Immobilization lasted 4 wk, with the original cast replaced at 2 wk or when limb movement within the cast was apparent. Control rats were pair fed. The animals were housed in a temperature and light-controlled room. After 4 wk, the rats were killed by cervical spinal cord separation and the gastrocnemius, soleus and triceps longus were quickly removed and weighed. Measurements: muscle weight; calcium, magnesium and zinc content of muscles.

IMMOBILIZATION METHOD: Plaster of Paris cast

RESULTS: There was a significant increase in the calcium content of gastrocnemius muscles from immobilized limbs. There were also significant increases in calcium within the various muscle fiber types after 4 wk of cast immobilization. A non-immobilized forelimb muscle, in rats with hindlimb immobilization, did not show a significant change in calcium after 4 wk of hindlimb immobilization. No significant change in whole gastrocnemius magnesium or zinc concentration was noted after 4 wk of immobilization.

SOURCE: Calcified Tissue Research 13: 327-330, 1973

AUTHOR(S): Booth, F.W. and J.R. Kelso

EXPERIMENT TITLE: Cytochrome Oxidase of Skeletal Muscle: Adaptive Response to Chronic Disuse

SUBJECTS: Rats

AREA OF STUDY: Muscular; Metabolism

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats - chronic disuse of rat hind-limb skeletal muscles was produced for 4 wk by application of plaster of Paris to both hind limbs so that ankle, knee and hip joint were immobilized at resting angles. Casts were replaced after 2 wk so that immobility within casts was maintained. Rats were sacrificed by cervical spinal cord separation, and the soleus, rectus femoris and gastrocnemius muscles were dissected. Portions of the "red" part of the rectus femoris and gastrocnemius and the "white" part of the gastrocnemius were removed. Measurements: cytochrome oxidase activity.

IMMOBILIZATION METHOD: Plaster of Paris casts

RESULTS: The cytochrome oxidase activities were significantly lower in the "red" portions of the rectus femoris and gastrocnemius muscles. There was no significant change in the cytochrome oxidase activity within the "white" portion of the gastrocnemius after 4 wk of disuse. There was no significant decrease in the cytochrome oxidase activity of the soleus.

SOURCE: Canadian Journal of Physiology and Pharmacology 51: 679-681, 1973

AUTHOR(S): Booth, F.W. and J.R. Kelso

EXPERIMENT TITLE: Production of Rat Muscle Atrophy By Cast Fixation

SUBJECTS: 16 Male Sprague-Dawley rats, 80 days old

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 8 controls, nonimmobilized; 2) 8 experimental rats, plaster casts applied to both hindlimbs for 28 days. The cast was applied with the hindlimb at a resting angle. Galvanized 4 x 4 mesh wire was modeled over the plaster on the hindlimbs and strips of plaster were applied dorsally to connect the casts of the hindlimbs and immobilize the hip joints. Casts were replaced after 2 wk. Rats were killed at the end of experiment and muscles were excised. Measurements: weight of adrenal glands, gastrocnemius, soleus, plantaris, and rectus femoris muscles.

IMMOBILIZATION METHOD: Plaster of Paris cast and mesh wire

RESULTS: Muscles atrophied due to immobilization. No significant differences were noted in adrenal gland weight; no ulcers were observed. No skin ulcers or foot swelling were observed on the immobilized hindlimbs.

SOURCE: Journal of Applied Physiology 34: 404-406, 1973

AUTHOR(S): Booth, F.W. and J.R. Kelso

EXPERIMENT TITLE: Effect of Hind-Limb Immobilization on Contractile and Histochemical Properties of Skeletal Muscle

SUBJECTS: Male Sprague-Dawley rats (70-80 days old)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats - plaster of Paris was applied to both hind limbs of rats so that ankle, knees and hip joints were fixed approximately at their resting angles for 4 wk. Two wk after casting, the initial cast was replaced with a second one around the smaller limbs. The soleus or rectus femoris were dissected free. The distal tendons of the muscles were attached to transducers for the measurement of contractile properties (contraction times, half relaxation times, tetanus fusion frequencies). Serial sections of hind limb muscles were stained for ATPase and NADH diaphorase. Muscle fibers with high enzyme activities of both ATPase and NADH-diaphorase were called FO (fast-twitch and high oxidative fibers); fibers with high activity of myosin ATPase and low activity of NADH-diaphorase were termed F (fast-twitch and low oxidative fibers); and fibers with low activity of myosin ATPase and moderate activity of NADH-diaphorase were called SO (slow-twitch and moderate oxidative fibers). Fibers were identified as to type and were counted.

IMMOBILIZATION METHOD: Plaster of Paris cast

RESULTS: In the soleus from the immobilized limb a significant decrease occurred in both the total number and percentage of SO fibers and there was a significant increase in the percentage of FO fibers. The contraction time of the soleus was significantly shorter than that of the controls. The tetanus fusion frequency for the soleus from immobilized limbs was higher than that of controls. The deep area of the rectus femoris from immobilized limbs showed a decrease in the percentage of FO fibers while the percentage of F fibers was significantly higher.

SOURCE: Pfluegers Archiv 342: 231-238, 1973

AUTHOR(S): Booth, F.W.

EXPERIMENT TITLE: Time Course of Muscular Atrophy During Immobilization of Hindlimbs in Rats

SUBJECTS: Female Wistar rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Both hind limbs were immobilized via plaster of Paris. In one series, the ankle and foot were fixed in slight plantar flexion (PF); in the other series, the foot was fixed in dorsal flexion (DF). Casts were changed at 2-wk intervals. In the PF experiment, rats weighing 282 ± 2 gm on day of fixation were killed at 2, 4, 7, 10 or 28 days; for DF rats, those weighing 267 ± 2 were killed at 2, 8, 20, 50 and 65 days. In both PF and DF groups, a subgroup of rats was killed on the day of immobilization, which served as a reference for the percentage of atrophy occurring during immobilization. Measurements: body weight; citrate synthase, myoglobin, protein, cytochrome c, and water content of the gastrocnemius, plantaris, soleus, tibialis anterior, and quadriceps muscles.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: In muscles whose lengths were at less than resting length during the fixation procedures, exponential decay to a new apparent steady state after atrophy was shown by wet and dry muscle weights and by the amounts of biuret protein, cytochrome c, and citrate synthase. The time for the decrease to $\frac{1}{2}$ of the final decrease at the new apparent steady state level was about 4-6 days for the above parameters that decayed exponentially. Myoglobin concentration increased during atrophy and the amount remained unchanged during atrophy. Onset of atrophy was delayed when muscles were stretched greater than resting length.

SOURCE: Journal of Applied Physiology 43: 656-661, 1977

AUTHOR(S): Booth, F.W.

EXPERIMENT TITLE: Regrowth of Atrophied Skeletal Muscle in Adult Rats
After Ending Immobilization

SUBJECTS: Female Wistar rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two experimental groups: 1) 28-day immobilization, followed by recovery period during which groups of rats were killed at 0, 3, 6, 10, 16 and 50 days; 2) 10-day immobilization, followed by recovery period during which rats were killed at 0, 3, 6, 10, 16 and 38 days. Both hind limbs of the rats were immobilized with plaster of Paris casts. In the above 2 experiments, a control group was killed on the day that hindlimbs were immobilized. Another control group was killed at the ends of these experiments - at the 50th and 38th days of recovery from prior immobilization in experiments 1 and 2, respectively. Diet: Wayne laboratory chow and water ad libitum. Measurements: body weight; gastrocnemius and soleus weight; citrate synthase activity; myoglobin concentration; protein concentration.

IMMOBILIZATION METHOD: Plaster of Paris cast

RESULTS: The reduction in the mean body weights ranged from 40 to 61 gm after 28 days of immobilization. 10-day immobilization - a mean loss of 30-37 gm occurred in the body weights. Significant atrophy of the gastrocnemius muscle after 10- and 28-days of immobilization; mean weight of the gastrocnemius in the group killed after 38 days recovery was significantly less than the mean gastrocnemius weight in either the control group killed on the first day of immobilization or the 38th day of recovery. After 50 days recovery from 28-day immobilization, the gastrocnemius muscle weight was not significantly different from that of controls killed on the 1st day of immobilization or the 50th day of recovery. There were no increases in the amounts of total protein or of citrate synthase activity in gastrocnemius or soleus during the 1st 3 days of recovery; thereafter there were increases in these parameters. Citrate synthase activities per mg of gastrocnemius protein were significantly higher at the 16th and 50th day of recovery. No significant differences for citrate synthase activity per mg of soleus occurred during recovery. Until the 50th day of recovery no significant differences for total protein in soleus and for total protein and wet weight of gastrocnemius were observed between control and recovery values. The wet weight of the soleus returned rapidly during recovery and was not significantly different from control during recovery.

SOURCE: Journal of Applied Physiology: Respiratory, Environmental and Exercise Physiology 44(2): 225-230, 1978

AUTHOR(S): Bouyer, J.J., L. Dedet, O. Debray, and A. Rougeul

EXPERIMENT TITLE: Restraint in Primate Chair May Cause Unusual Behavior in Baboons; Electrocorticographic Correlates and Corrective Effects of Diazepam

SUBJECTS: 8 Baboons (Papio papio)

AREA OF STUDY: Nervous; Pharmacology

OBJECTIVES: In title

PROTOCOL: Two groups: electrocorticogram (ECoG) leads implanted in the somatic and motor areas of the baboons; after 1 week the ECoG was taken when: 1) moving freely in a large cage; or 2) restrained in a chair with the animal's hands or head attached. Diazepam was administered (2 mg/kg im) and recording continued for 1 hr.

IMMOBILIZATION METHOD: Chair

RESULTS: When the ECoG was recorded from the somatic area an unusual pattern developed during the restrained state: "drowsiness rhythms" which appear during transition from wakefulness to sleep, developed in long sustained sequences. Administration of diazepam caused both the behavior and the ECoG of the restrained baboon to return to normal.

SOURCE: Electroencephalography and Clinical Neurophysiology 44: 562-567, 1978

AUTHOR(S): Bowersox, S.S., J.M. Siegel, and M.B. Sterman

EXPERIMENT TITLE: Effects of Restraint on Electroencephalographic Variables and Monomethylhydrazine-Induced Seizures in the Cat

SUBJECTS: 12 Cats (2.7-5.5 kg)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Two groups of 6 each: 1) naive, unoperated cats (5 females, 1 male); 2) operated cats, electrodes surgically implanted for monitoring the EEG (4 females, 2 males). Animals were subjected to 2 injections of monomethylhydrazine (MMH) under 2 conditions, restrained and unrestrained. Intertrial intervals ranged from 32-137 days. Cats were restrained by securing them in a tightly fitting nylon net bag which was drawn closed about the neck. Latency to seizure was measured from the time of injection to the onset of tonic-clonic convulsions. Measurements: EEGs; behavioral observations; weight changes; latency to seizure time.

IMMOBILIZATION METHOD: Nylon net bag

RESULTS: Susceptibility to seizures was significantly decreased under the condition of restraint. Polygraphic recordings showed that restraint was accompanied by an increased incidence of synchronous patterns. These results were not explained by metabolic variables, duration of intertrial interval, or changes in weight.

SOURCE: Experimental Neurology 61: 154-164, 1978

AUTHOR(S): Boyer, V.A. and A.G. Rakochi

EXPERIMENT TITLE: Effect of Hypokinesia and Muscular Overloads on Animal Heart Action

SUBJECTS: 165 White rats, 6-8 mo old

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 114 rats kept hypokinetic in cages 23.5 hr daily for 2 wk; 2) 51 rats given muscular overloads by daily running on a treadmill till exhaustion for 2 wk; 3) controls. Measurements: ECG; weight of body and heart.

IMMOBILIZATION METHOD: Cage

RESULTS: Under conditions of restricted mobility and muscular overloading, unidirectional changes in heart action developed in the rats. In both groups, the cardiac rate at rest increased, the reaction of the rhythm of the heart and its restoration were slow to develop under a dynamic load and monotypic shifts in the phase structure of the systole took place incident to muscular stress. In hypokinetic and overtrained rats an increase in the absolute and relative duration of the stress period and a decrease in the expulsion period was observed.

SOURCE: Kosmicheskie Issledovaniya na Ukraine No.4: 36-41, 1973

AUTHOR(S): Britvan, I.I. and M.A. Dotsenko

EXPERIMENT TITLE: Changes in the Morphological Composition of the Blood and Bone Marrow During Hypokinesia and Pressure Chamber Training

SUBJECTS: Male rats

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: Three groups: 1) rats were adapted to hypoxic hypoxia in a pressure chamber for 10 days at 3,000, 5,000 then 7,000 m altitudes for 6 hr daily then subjected to hypokinesia in a cage for 30 days; 2) hypokinesia for 30 days; 3) controls. Measurements: hemoglobin, erythrocytes in bone marrow and blood.

IMMOBILIZATION METHOD: Cage

RESULTS: Adaptation to hypoxic hypoxia caused a significant increase in hemoglobin content and erythrocytes. It stimulated activity of the erythroblastic elements and caused a depression of the myeloid series. On the 10th and 30th day of hypokinesia, there were decreases in hemoglobin and erythrocytes. Unadapted hypokinetic rats on the 10th day demonstrated increased hemoglobin and erythrocytes due to hemoconcentration from increased diuresis. By the 30th day there was a decrease in the number of erythroblastic elements in the red series; hemoglobin and erythrocytes approached the initial level.

SOURCE: Aktual'nye Voprosy Kosmicheskoi Biologii i Meditsiny (ed. by O.G. Gazonko et al), Moscow, 1971, pp. 32-33.

AUTHOR(S): Brodie, D.A. and H.M. Hanson

EXPERIMENT TITLE: A Study of the Factors Involved in the Production of Gastric Ulcers By the Restraint Technique

SUBJECTS: Male Wistar mice (15-25 gm); male Holtzman rats (50-350 gm); male guinea pigs (200-300 gm); male hamsters (105-120 gm); male albino rabbits (800-1000 gm); male and female rhesus monkeys (2.2-2.5 kg)

AREA OF STUDY: Digestive

OBJECTIVES: Studied effects in 6 species

PROTOCOL: Twelve groups: 1) mice restrained for 24 hr by wrapping them in galvanized wire screen fastened with wire or bolts; 2) rats restrained for 24 hr; 3) guinea pigs restrained for 24 hr; 4) hamsters restrained for 24 hr; 5) rhesus monkeys restrained for 24 hr; 6) rats restrained for 6, 12, 18 or 24 hr, then allowed to recover for 12, 24, 48 and 72 hr; 7) rats deprived of food for 30 or 54 hr; 8) rats deprived of food for 30 hr, restrained for the last 6; 9) rats deprived of food for 54 hr, restrained for the last 6; 10) rats hypophysectomized, restrained for 6 or 24 hr; 11) rats vagotomized, restrained for 6 or 24 hr; 12) rats adrenalectomized, restrained for 6 or 24 hr. Animals were killed, their stomachs excised and examined. Measurements: incidence, number, and degree of gastric lesions.

IMMOBILIZATION METHOD: Galvanized steel window screen fastened with wire or bolts

RESULTS: Mice, rats, guinea pigs, and hamsters had gastric ulceration rates of 92, 86, 46 and 4%, respectively, after 24 hr restraint; restraint did not induce gastric ulcers in rabbits or monkeys. Increase of restraint from 6 to 24 hr in rats increased gastric ulcer incidence. Recovery took 72 hr after 24-hr restraint. Food deprivation caused a higher incidence of gastric ulcers in rats and prolonged the time required for gastric mucosa to return to normal. Younger rats (50-185 gm) had a higher gastric ulceration rate than older rats (over 250 gm) under short restraint; weight was not an important factor in 24-hr restraint. Repeated restraint periods (18 hr/day) increased the incidence and severity of gastric ulcers and produced rumen ulcers. In rats, 8 days postoperation, hypophysectomy and bilateral subdiaphragmatic vagotomy did not significantly reduce the incidence of animals with ulcers. Bilateral adrenalectomy significantly increased the incidence and severity of restraint-produced ulcers.

SOURCE: Gastroenterology 38: 353-360, 1960

AUTHOR(S): Brodie, D.A., R.W. Marshall, and O.M. Moreno

EXPERIMENT TITLE: Effect of Restraint on Gastric Acidity in the Rat

SUBJECTS: Male Holtzman rats (163-196 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Gastric secretion was measured in A) 16 chronic gastric fistula rats, implanted with stainless steel cannulas in the rumen portion of the stomach: Groups - 1) restrained (24 hr) in wire screen; and 2) unrestrained; B) 10 pylorus-ligated rats (prepared by the Shay et al. method): Groups - 1) restrained (24 hr) in wire screen; and 2) unrestrained. Measurements: volume, free acidity and total acidity of gastric juice.

IMMOBILIZATION METHOD: Wire screen

RESULTS: Volume of gastric content, free and total acidity, and free acid output were significantly lower in the chronic fistula rats as compared to the pylorus-ligated rats. Restraint in chronic fistula rats produced a significant decrease in volume, a significant increase in free and total acid concentration, and no change in free acid output. Restrained pylorus-ligated rats had a significant decrease in volume, no change in free or total acid concentration, and a significant decrease in free acid output as compared with control values.

SOURCE: American Journal of Physiology 202: 812-814, 1962

AUTHOR(S): Brodie, D.A. and L.S. Valitski

EXPERIMENT TITLE: Production of Gastric Hemorrhage in Rats by Multiple Stresses

SUBJECTS: Male Holtzman rats (120-150 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls; 2) experimental rats were starved for 24 hr then restrained by stapling them into a piece of window screen or perforated conduit tubing plugged with corks at each end and put in a cold environment for 15, 30 or 60 min; 3) experimental rats administered - anticholinergics, ganglionic blocking agents, CNS depressants and epinephrine prior to cold and restraint. Some animals were pylorus-ligated to study gastric secretion and in some the vessels supplying the stomach were ligated to study the relationship between blood supply and lesions. Measurements: stomach lesions; volume and acidity of gastric content.

IMMOBILIZATION METHOD: Window screen; Perforated conduit tubing and corks

RESULTS: Gastric hemorrhage was produced in 93% of rats subjected to cold + restraint stress for 60 min. Mucosal damage was not evident and could not be induced by repeated stress. Anticholinergics, ganglionic blocking agents, CNS depressants and epinephrine reduced the incidence of hemorrhage, gastric volume was reduced by cold + restraint in the pylorus-ligated and chronic gastric fistula rat, while gastric acidity was only reduced during stress in the fistula rats. The cold + restraint produced a marked hypothermia.

SOURCE: Proceedings of the Society for Experimental Biology 113: 998-1001, 1963

AUTHOR(S): Brooke, J.W. and H.G. Bewick Slack

EXPERIMENT TITLE: Metabolism of Connective Tissue in Limb Atrophy
in the Rabbit

SUBJECTS: Young adult rabbits (1.8-2 kg)

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Six rabbits were completely paralyzed in the left hind limb by extensive neurectomy and sympathectomy. Fourteen days after the operation, $x^{14}\text{C}$ -glycine and ^{35}S labelled sodium sulphate were injected subcutaneously and the animals were killed at 10 hr, 24-hr, 2 days, and 4 days afterward. From the atrophying limb and normal limb of each animal, tissues were separated into a soft tissue compartment and a skeletal compartment. Measurements: collagen (neutral salt-soluble, acidic citrate-soluble, insoluble); sulphated polysaccharide.

IMMOBILIZATION METHOD: Neurectomy and sympathectomy

RESULTS: There is evidence of continued synthesis of collagen in both skeletal and soft tissues of the atrophying limbs. The most marked reductions in metabolic activity were found in the soft tissue compartment and particularly in the neutral salt-soluble collagen. The main portion of the sulphated polysaccharide also showed some reduced metabolic activity, most marked in the soft tissues.

SOURCE: Annals of the Rheumatic Diseases 18: 129-136, 1959

AUTHOR(S): Brooks, F.P., P. Ridley, F. Attinger, and K. Neff

EXPERIMENT TITLE: Effect of Restraint on Fasting Gastric Content of Spider Monkeys

SUBJECTS: 2 Spider monkeys

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control, free movement; 2) experimental, restrained in a chair for 24 hr. Hourly collections of fasting gastric content were made with chronic gastric fistulae during the experiment. Measurements: volume; free acid concentration; total acid concentration; pepsin concentration.

IMMOBILIZATION METHOD: Chair

RESULTS: There was little change noted in volume and acid concentration throughout the study when the animals were restrained. In contrast the free moving animals showed a greater volume during the period of daytime activity than when they were restrained, but exhibited a marked decrease in volume and acid concentration during the night. The pepsin concentration during the first 9 hr was significantly greater in the restraint experiment.

SOURCE: American Journal of Physiology 205: 1093-1095, 1963

AUTHOR(S): Brown, M.S. and W.G. Groves

EXPERIMENT TITLE: Intestinal Propulsion in Restrained and Unrestrained Rats

SUBJECTS: Male Wistar rats (70-150 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Four groups: 1) controls; 2) restrained; 3) unrestrained and dichloroisoproterenol (DCI) treated; 4) restrained and DCI treated. All animals were allowed to consume only water for 24 hr before the test meal. In groups 3 and 4, the hydrochloride salt (in 1 ml/kg aqueous solution) of a beta adrenergic blocking agent, DCI, was injected sc; the test meal followed in 30 min. Groups 1 and 2 animals were injected with 1 ml/kg of saline instead of DCI. The test meal which consisted of 5 ml/kg of a 6% suspension of charcoal powder in 0.5% tragacanth was administered by gavage. Immediately after the test meal, animals in groups 2 and 4 were individually restrained by taping together the forelimbs and the hindlimbs and taping the tail to the body; each rat was then wrapped in a piece of galvanized steel window screen which was molded to the animal's body and stapled firmly. Groups 1 and 4 animals were returned to their cages. All animals were deprived of food and water for the remainder of the experiment. Animals were sacrificed 5-240 min after the test meal and the intestines were removed. Measurement: propulsion activity of the intestine.

IMMOBILIZATION METHOD: Galvanized steel window screen and tape

RESULTS: 5-45 min following the test meal, the velocity of the meal was related inversely to time after dosing and declined exponentially with increasing distance from the pylorus. Meal velocity was halved for every advance of 11% intestinal length. These relationships generally persisted for restrained rats despite reduction in the overall velocity of the meal through the intestine. DCI partially reversed the velocity decrease in restrained rats

SOURCE: Proceedings of the Society for Experimental Biology and Medicine 121(4): 989-992, 1966

AUTHOR(S): Brumberg, V.A. and L.Z. Pevzner

EXPERIMENT TITLE: RNA Content in Motor and Sensory Neurons and Surrounding Neuroglia of Mouse Spinal Cord Under Conditions of Hypodynamia and Following Normalization

SUBJECTS: Male white mice (28-32 gm)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Hypodynamia, 2-3 wk, followed by immediate decapitation, or decapitation 2, 6, 24 and 72 hr after a 3 wk hypodynamia. Measurements: cytoplasmic RNA content per cell by means of ultraviolet cytospectrometry.

IMMOBILIZATION METHOD: Compartment (plexiglas, 7 x 2.5 x 2.5 cm)

RESULTS: The first few days after the mice were placed in the compartments they showed agitation, then gradually they became accustomed to the hypodynamic conditions and, in the long run, behaved quietly, sitting motionless in the compartments. Toward the end of 3 wk of hypodynamia, a series of signs called a "hypokinetic complex" became noticeable in the animals: loss of body weight (about 15-20%), paresis of the dorsal end and loss of motor coordination. Normal motor activity in these mice was restored only after 2-3 days following the discontinuation of a 3 wk hypodynamia. Two and three wk hypodynamia did not influence the RNA content of the neurons in the ventral horns of the spinal cord, the body of neuroglia surrounding these cells, or the neurons of the sensory spinal ganglia. In the glial cellular satellites of the ganglia, the RNA content was distinctly increased at the end of 2 wk and sharply decreased at the end of 3 wk of hypodynamia. After a 3 wk hypodynamia in the first 2 hr following release, the quantity of RNA decreased in the neurons and neuroglia in the ventral horns of the spinal cord, as well as in the spinal ganglia. In the course of 24 hr there was a gradual restoration of initial levels of RNA in the neural and glial cells; the rate of restoration was higher in the glials than in the neurons. After 3 days RNA content was normalized in the motor nuclei of the spinal cord as well as in the sensory spinal ganglia; it decreased in the neuroglia.

SOURCE: Tsitologiya 10(11): 1452-1459, 1968

AUTHOR(S): Brumberg, V.A., O.G. Gazenko, N.N. Demin, V.B. Malkin,
and L.Z. Pevzner

EXPERIMENT TITLE: Topochemical Differences in the Content of RNA in
the Motor Neurons of the Spinal Cord During Hypoxia
and Hypokinesia

SUBJECTS: 20 Sexually mature male white rats (100 ± 20 gm)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Four groups: 1) hypoxia; 2) hypokinesia; 3) hypoxia plus
hypokinesia; 4) controls. Each group contained 5 animals. Rats subjected
to hypoxia were placed in a pressure chamber at first at an altitude of
3000 m, then it was increased daily over a period of 7 days by 500-1000 m,
and then the animals were kept at an altitude of 7000 m for 14 days.
Daily exposure was 6 hr. Rats subjected to hypokinesia by placing them
in box cages with a small volume for 20 days. 25-30 cells were taken
from each animal for investigation. At the end of the experiment the
rats were decapitated and portions of the spinal cord in the region of
the lumbar and cervical swellings were extracted. Before and after
extraction, portions of the cytoplasm of the motor neurons were subjected
to UV cytospectrophotometry. Measurements: RNA concentration; volume of
cytoplasm of neurons; amount of RNA calculated per cell.

IMMOBILIZATION METHOD: Cage (small volume)

RESULTS: Hypokinesia alone decreased the concentration of cytoplasmic
RNA in the motor neurons; RNA concentration in the motor neurons of the
lumbar enlargement was significantly higher than controls in all experi-
mental groups. Hypokinesia led to a distinct increase in the volume of
the cytoplasm in motor neurons of both sections of the spinal cord while
the hypokinesia/hypoxia combination caused a similar increase only in
neurons of the cervical enlargement.

SOURCE: Doklady Akademii Nauk SSSR 205(6): 1490-1493, 1972

AUTHOR(S): Buchel, L. and D. Gallaire

EXPERIMENT TITLE: Reduction of the Duration of Restraint for the Production of Experimental Ulcers in Rats. Application to the Study of Protective Substances

SUBJECTS: Wistar rats, ~ 50 days old (120-140 gm)

AREA OF STUDY: Digestive; Pharmacology

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 146 rats without prior fast, subjected to 1, 2, 4, 5 or 7 hr restraint wrapped in wire gauze with holes for feet, feet wrapped in pairs by adhesive tape, then suspended horizontally on a stand; 2) 60 rats subjected only to fast of 2 1/2, 7 or 24 hr; 3) 219 rats subjected to a 24 hr fast followed by a 2 or 2 1/2 hr restraint; animals in this group were also administered atropine, dihexyverine, or chlorpromazine ip, immediately after immobilization or 2 1/2 hr before sacrifice. Subjects received no food or water during restraint. Stomachs were examined after decapitation. Measurements: percentage of ulcerated stomachs; average index (number of ulcers per animal).

IMMOBILIZATION METHOD: Wire gauze, adhesive tape, and stand

RESULTS: Production of ulcers: rats subjected to restraint without prior fast developed an irregular percentage of ulcers, which reached 55% with a restraint of 7 hr (average index 1.4). Animals subjected to fast only developed a low percentage of ulcers, 5-10%, (average index 0.1-0.2). With a prior fast of 24 hr, a 2 1/2 restraint regularly gave rise to ulcer formation in 82% to 85% of the rats, (average index 2.5-2.8). Protection from ulcers: the dose of atropine effective was 1.25 mg/kg; 20% of rats developed ulcers (average index 0.2). With dihexyverine and chlorpromazine the degree of protection was a function of the dose utilized; rats administered doses of 10-50 mg/kg of these substances developed ulcers in 25-60% of the cases, (average index 0.3-1.4).

SOURCE: Comptes Rendus des Seances de la Societe de Biologie et de ses Filiales 157(6): 1225-1228, 1963

AUTHOR(S): Buchel, L. and D. Gallaire

EXPERIMENT TITLE: Influence of Ambient Temperature on the Production of Restraint Ulcers in the Rat

SUBJECTS: Female Wistar rats, 6 wk old (110-120 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Three groups: 1) restraint for 2 1/2 hr, preceded by 24 hr fast; 2) restraint without prior fasting; 3) controls. Restraint was created by fitting flexible wire mesh over the rats' bodies with limbs protruding, paws attached in pairs with adhesive tape. Each group subjected to temperatures of 32, 28, 24, 22, 19 and 14°C. Measurements: rectal temperature of animals; percentage of animals developing ulcers; average ulcer index.

IMMOBILIZATION METHOD: Wire mesh

RESULTS: Group 1 (restraint and fasting): as temperature fell below 24°C, the frequency of ulcers rose regularly, reaching 95% at 14°C; the average index rose in a parallel manner. Group 2 (restraint without fasting): less sensitivity to the ulcerogenic action of restraint at all ambient temperatures. Running parallel to the elevation in frequency of ulcers was a significant lowering of rectal temperature at the end of restraint.

SOURCE: Comptes Rendus des Seances de la Societe de Biologie et de ses Filiales 160(10): 1817-1820, 1966

AUTHOR(S): Buchel, L. and D. Gallaire

EXPERIMENT TITLE: Restraint Ulcers in the Rat: Influence on Ulcer
Frequency of Fasting and of Environmental Temperature
Associated with Immobilization of Varying Durations

SUBJECTS: Wistar rats

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: The restraint condition was produced by immobilizing the animal in wire gauze. Groups: 1) restraint without prior fast - 20 rats, 1-7 hr, rats were fed normally just at the time of immobilization or deprived of food but not water before the application of restraint; 2) restraint with prior hydrated fast - groups of 20, 39, and 140 rats, prior fast of 24 hr, restraint of 2-1/2 hr; 3) restraint with variations in environmental temperature concomitant with prior fasting - 24 hr fast, restraints of 1-1/2 and 2-1/2 hr, at different ambient temperatures, kept constant during the duration of the experiment, but ranging from 14 to 32°C. Measurements: percentage of rats bearing ulcers; number of ulcers per rat (average index).

IMMOBILIZATION METHOD: Wire gauze

RESULTS: Restraint without prior fast: the percentage of animals bearing ulcers remained at approximately 40% (average index: 0.7) when the duration of restraint was increased from 2-1/2 to 5 hr; it reached 55% (average index: 1.40) after a restraint of 7 hr. Restraint with prior hydrated fast: in animals thus prepared, a restraint of 2-1/2 hr regularly caused, in groups of 20, 39, and 140 rats ulcer formation in 82, 83, and 85% (average index 2.5-2.8). Restraint with variations in environmental temperature concomitant with prior fasting: 1-1/2 hr restraint - exerted only a weak ulcerogenic action at ambient temperatures of 28 and 32°C, but became effective when the temperature dropped - at 19°C, 66% of animals developed ulcers, at 14°C, 75% (average index: 2.05±0.50) developed ulcers; 2-1/2 hr restraint - percentage of animals bearing ulcers did not exceed 35% with temperature between 24 and 32°C; as temperature falls below 24°C, the frequency of ulcers increased and reached 95% at 14°C, at the same time that the severity of the ulcers (average index) was augmented.

SOURCE: Archives des Sciences Physiologiques 21: 527-536, 1967

AUTHOR(S): Buchel, L., L. Liblau, M. Murawsky, and M. Prioux-Guyonneau

EXPERIMENT TITLE: Influence of Psychotropic Substances on the Variation of Free Fatty Acid Plasma Levels in Restrained Rats

SUBJECTS: 600 Female Wistar rats, 7-8 wk old (130-150 gm)

AREA OF STUDY: Pharmacology; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Sixteen groups: chlorpromazine (ip at onset of restraint), dextromoramide (ip 15 min before restraint), phenobarbital (ip 15 min before restraint) and iproniazide (ip 24 hr before restraint) were each administered to 2 groups of rats, 1 group was restrained for 2½ hr in flexible metallic cloth cylinders, 1 group remained unrestrained. For each psychotropic substance there were 2 control groups, 1 unrestrained, 1 restrained, both groups received physiological saline ip. Animals were subjected to a 24 hr water fast before restraint, and maintained at 23°C; groups of animals administered chlorpromazine and phenobarbital were additionally maintained at 29°C. Blood was drawn by cardiac puncture after light ether anesthesia. Measurements: free fatty acid plasma level, total blood glycemia, rectal temperatures, degree of gastric attack by number of animals developing ulcers and the number and severity of lesions per animal.

IMMOBILIZATION METHOD: Metal cloth cylinder (flexible)

RESULTS: Chlorpromazine and phenobarbital suppressed the lowering of the free fatty acid plasma level in restrained rats. Dextromoramide and iproniazide did not modify the lipid metabolism in the restrained rat. No relationship between the protection of the gastric mucosa and the correction of metabolic disorders was found. The hypothermia produced by chlorpromazine and phenobarbital was not responsible for the antagonistic effects exercised by these 2 substances toward the metabolic modifications induced by restraint.

SOURCE: Archives des Sciences Physiologiques 23(2): 407-414, 1969

AUTHOR(S): Buchel, L. and M. Murawsky

EXPERIMENT TITLE: Metabolism and Activity of Zoxazolamine in White Rats During Forced Immobilization With and Without Hyperthermia

SUBJECTS: Female Wistar rats (135-187 gm), 8-10 wk old

AREA OF STUDY: Pharmacology

OBJECTIVES: In title

PROTOCOL: Four groups: 1) restrained at normal body temperature for 30 min to 18 hr at 27°C; 2) restrained with hypothermia at 10°C for 30 min to 18 hr; 3) controls, nonrestrained at normal body temperature; 4) controls, nonrestrained at 10°C. All animals were fasted 24 hr prior to experiment. At the end of restraint, all animals received 1% zoxazolamine solution ip, 0.2-0.6 ml/100 gm body weight. Animals were allowed to recover from zoxazolamine induced paralysis, then killed. Blood was taken; stomach, brain and liver excised and analyzed. Measurements: time required to recover from zoxazolamine paralysis; incidence and degree of gastric ulcers; zoxazolamine levels of blood, brain and liver.

IMMOBILIZATION METHOD: Wire mesh cylinder

RESULTS: Group 1 rats restrained at normal body temperature: a) at an ambient temperature of 22°C, a 40 mg/kg dose was effective in 50% of the animals; the 50 and 60 mg/kg doses produced significantly longer durations of paralysis, the potentialization did not intensify with the duration of restraint; b) at an ambient temperature of 27°C, there was a shorter duration of paralysis. At 10 to 60 min after administration of zoxazolamine, the blood and cerebral levels of the free and restrained rats were not significantly different; the hepatic level, originally higher in restrained animals, declined over the period; 90-240 min after zoxazolamine, blood/cerebral levels were lower, hepatic levels were not significantly different. Group 2 rats restrained with hypothermia: a 50 mg/kg dose had a significantly longer effect, even after a restraint of 30 min; potentialization intensified with prolongation of restraint, which produced greater hypothermia; the normally inactive doses of 10/20 mg/kg became effective after 90-120 min restraint.

SOURCE: Archives des Sciences Physiologiques 27: 37-53, 1973

AUTHOR(S): Buchel, L., M. Prioux-Guyonneau, and L. Libiau

EXPERIMENT TITLE: Adrenocortical Response in Rats Subjected to a Stress of Restraint By Immobilization Whether Accompanied By Hypothermia or Not

SUBJECTS: Female Wistar rats, 8 wk old (180-200 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Two series: 1) free rats (influence of the experimental conditions on the plasma and adrenal levels of corticosterone) - groups: a) fasted; b) 15, 30, 60 min after ether inhalation; c) 15 and 60 min after manipulations preceding immobilization; d) exposure to cold, 10°C. Series 2) rats restrained in flexible metallic cylinder - groups: a) immobilization, 1-5 hr at 28, 24 or 10°C; b) immobilization, 1 or 2 1/2 hr, measurements taken 1 1/2, 2 1/2, 3 1/2, and 17 hr after the end of restraint, at 24°C or 10°C. All experiments were performed in groups of 10 rats each, all received 3 min of ether inhalation. Measurements: plasma and adrenal corticosterone.

IMMOBILIZATION METHOD: Flexible metallic cylinder

RESULTS: Series 1 - Free rats: fasting did not change the corticosterone levels; ether inhalation and the manipulations preceding immobilization did provoke an increase in the plasma and adrenals which disappeared after 60 min. Exposure to cold created a slight hypothermia. The increase in corticosterone level was significant when the animals were maintained for 1 to 2 1/2 hr at 10°C. Series 2 - Restrained rats: restraint provoked an increase in adrenocortical activity. Rats maintained in normothermia (28°C) or a slight hypothermia (24°C) sustained an elevation of plasma and adrenal corticosterone concentration that was at least 3 times the normal concentration at all durations of restraint (1-5 hr). Exposure to cold (10°C) created a significant hypothermia. The corticosterone levels here were of the same order of magnitude as those of the restrained rats maintained at 24°C or at 28°C. Corticosterone levels were clearly lowered 2 1/2 hr after the end of restraint of 1 hr at 24°C; 3 1/2 hr later, the levels became equal to those of the free controls. The normalization of corticosterone levels was slower in rats that had undergone a 2 1/2 hr restraint at 24°C: 3 1/2 hr after such restraint a significant difference was still present; no difference was detectable after 17 hr. Rats that underwent a 2 1/2 hr restraint at 10°C presented plasma and adrenal corticosterone levels greater than normal after 3 1/2 hr of rest; after 17 hr these levels were normalized.

SOURCE: Comptes Rendus des Seances de la Societe de Biologie et de ses Filiales 168(10-12): 1202-1207, 1974

AUTHOR(S): Bukayeva, I.A.

EXPERIMENT TITLE: Changes in Composite Muscles During Hypokinesia

SUBJECTS: 110 Rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinesia for 100 days. The condition of the gastrocnemius and quadriceps muscles were studied by histological and biometric methods. Material for examination was taken on days 1, 3, 5, 10, 14, 20, 30, 45 and 60 of the experiment. Measurements: muscle weight; degree of atrophy.

IMMOBILIZATION METHOD: Not stated

RESULTS: The weight of the muscles decreased beginning on day 3 of hypokinesia; the greatest decrease was recorded after 45 days. The percentage weight loss of the gastrocnemius muscle was 48.8%, while that of the quadriceps muscle was 38.8%. The relative cross-sectional areas of both the thin and thick fibers in the two muscles decreased in the experimental rats. Atrophy of the thick fibers was clearly seen only on the 30th day, while they appeared far earlier in the thin fibers.

SOURCE: Eksperimental'nye Issledovaniya Gipokinezii, Izmenennoi Gazovoi Sredy, Uskorenii, Peregruzok i Drugikh Faktorov (ed. by V.V. Parin et al), 1968, pp. 9-11.

AUTHOR(S): Bukayeva, I.❧.

EXPERIMENT TITLE: Cytological Characteristics of the Red Muscle of Rats
During Restriction of Mobility

SUBJECTS: 110 Rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 55 controls; 2) 55 experimental rats kept in small restraint cages. Material for examination was taken 1, 3, 5, 10, 14, 20, 30, 45, 60 and 100 days after the experiment began and examined by histological and biometric methods. Measurements: body weight; soleus muscle weight; relative muscle-fiber area; state of muscle fibers.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: Beginning with day 3, the experimental rats exhibited a decrease in body weight which was statistically reliable at all intervals. The absolute weight of the soleus muscle in the experimental animals was lower than that of the controls throughout the experiment, except on the first day. The relative muscle-fiber area continuously decreased in the hypokinetic rats. In addition to altered atrophied muscle fibers, foci of greatly enlarged perimysial tissue were found on days 45 and 60. The muscle-fiber polymorphism was more pronounced after 100 days.

SOURCE: Eksperimental'nye Issledovaniya Gipokinezii, Izmenennoi Gazovoi Sredy, Uskoreniy, Peregruzok i Drugikh Faktorov (ed. by V.V. Parin et al), 1968, pp. 6-8.

AUTHOR(S): Burkhart, J.M. and J. Jowsey

EXPERIMENT TITLE: Parathyroid and Thyroid Hormones in the Development of Immobilization Osteoporosis

SUBJECTS: Male mongrel adult dogs (8-12 kg)

AREA OF STUDY: Endocrine; Skeletal

OBJECTIVES: To determine if osteoporosis observed with immobilization is the result of local factors or develops in response to circulating hormones.

PROTOCOL: The right hind limb of each dog was immobilized in a single hip spica plaster cast. Four groups: 1) glands intact (normal diet); 2) parathyroidectomized (normal diet plus calcium gluconate); 3) thyroidectomized (diet free of animal protein); and 4) thyroparathyroidectomized (normal diet). The serum calcium of each animal was measured weekly; protein-bound iodine was measured for groups 3 and 4 at the end of immobilization. After 3 to 12 wk immobilization the bones of the hind limbs of each animal were dissected free of soft tissue, and roentgenograms were taken of the femurs and metacarpals; the degree of porosity, bone formation, and bone resorption were measured in the midshaft of these 2 bones. The pCO₂, pO₂ and pH of arterial and venous tibial blood were measured in selected animals.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: Osteoporosis was indicated by both roentgenologic and micro-radiographic evidence after 3 wk; increased bone resorption continued for 8 wk when bone formation rose and showed further increase at 12 wk. Osteoporosis developed only in animals with intact parathyroid and thyroid glands. The immobilized limbs of intact animals showed an increased pCO₂ and decreased pH of bone blood; such changes did not appear in the control limbs or the immobilized limbs of animals without intact thyroids and/or parathyroid glands.

SOURCE: Endocrinology 81: 1053-1062, 1967

AUTHOR(S): Burton, R.R. and J.R. Beljan

EXPERIMENT TITLE: Animal Restraint: Application in Space (Weightless) Environment

SUBJECTS: Adult male Single-Comb White Leghorn chickens

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Three groups: 1) control, unrestrained in cages; 2) restrained by a nylon vest and leather ties so as to allow only perching; 3) restrained by a nylon vest and leather ties so as to allow squatting and perching. Restraint for group 2 animals lasted for 5 days and several trials for this period of time were performed on each animal. Group 3 animals were subjected to restraint for 3 months. Measurements: hematology (hematocrit, buffy coat and total plasma protein); plasma and blood volumes; arterial systolic blood pressure; pulse; respiratory rate.

IMMOBILIZATION METHOD: Nylon vest

RESULTS: Chronic restraint was found to produce a typical environmental type stress response. This included a lymphopenia and loss of body mass resulting in death if continued for several days. 50% of the restrained animals were affected. A restraint method was developed which was not physiologically stressful nor did it produce immobilization. The degree of restraint was considered sufficient as an animal orientation aid for space experimentation. These animals tolerated the form of chronic restraint for three months without significant changes in their hematology or physiological parameters.

SOURCE: Aerospace Medicine 41: 1060-1065, 1970.

AUTHOR(S): Burton, R.R., A.H. Smith, and J.R. Beljan

EXPERIMENT TITLE: Effect of Altered "Weight" Upon Animal Tolerance to Restraint

SUBJECTS: Adult male Single-Comb White Leghorn chickens

AREA OF STUDY: Behavior; Blood

OBJECTIVES: In title

PROTOCOL: Four groups: 1) weighted (increased weight), restrained; 2) weighted, non-restrained in cage; 3) counterweighted (reduced weight), restrained; 4) counterweighted, non-restrained. Fowl were fitted in either restraining or nonrestraining nylon vests, and either weighted dorsally ventrally with lead weights, or counterweighted (lifted) with lead weights and pulleys. Measurements: number of lymphocytes; body mass; degree of orientation syndrome indicated by an inability of the bird to find a normal, constant posture.

IMMOBILIZATION METHOD: Nylon vest

RESULTS: Weighting (increased weight) and counterweighting (reduced weight) produced a stressed condition, reduced relative lymphocyte counts, loss of body mass, and/or the development of a disorientation syndrome in both restrained and nonrestrained fowl. The animals' tolerance to altered weight appeared to be a function of body weight. Unrestrained birds were stressed by counterweighting $58.3 \pm 41\%$ of their body weight, whereas restrained birds tolerated only $32.2 \pm 2.6\%$ reduction in body weight. A training regimen for restrained birds was not effective in improving their tolerance to a reduced weight environment.

SOURCE: Aerospace Medicine 42: 1290-1293, 1971

AUTHOR(S): Bush, M., R. Custer, J. Smeller, and L.M. Bush

EXPERIMENT TITLE: Physiologic Measures of Nonhuman Primates During Physical Restraint and Chemical Immobilization

SUBJECTS: 23 Species of Callithricidae, Cebidae, Cercopithecidae, and Pongidae primates

AREA OF STUDY: Blood; Pharmacology

OBJECTIVES: In title

PROTOCOL: Animals were physically restrained by being held in the dorsal recumbent position (16-88 min); chemical restraint involved either injections of ketamine hydrochloride or combined tiletamine hydrochloride and zolazepam. Arterial blood was collected. Measurements: pH; pCO₂; pO₂; rectal temperature; pulse and respiration rate.

IMMOBILIZATION METHOD: Manual; Drug

RESULTS: Physically restrained animals had significantly lower pH, pCO₂, and base excess values, but significantly higher pO₂ values, rectal temperatures, and pulse and respiration rates. 30 (54%) of the 56 physically restrained animals had severe metabolic acidosis, with pH values less than 7.1. Some of the marmosets were excited during restraint, with a great deal of struggling and vocalizing; others were quiet and calm, with a minimum of struggling. The excited group had significantly lower pH, pCO₂, and base excess values, but significantly higher pO₂ values, rectal temperatures, and pulse and respiration rates. Chemical restraint produced a near normal acid-base balance and these animals were more easily handled than physically restrained animals.

SOURCE: Journal of the American Veterinary Medical Association 171(9): 866-869, 1977

AUTHOR(S): Bykov, G.P., A.V. Novikov, and S.M. Ivanova

EXPERIMENT TITLE: Morphology of the Liver and Skeletal Muscles During Hypokinesia and a Protein Deficit

SUBJECTS: 44 White male rats

AREA OF STUDY: Muscular; Digestive

OBJECTIVES: In title

PROTOCOL: Four groups: 1) hypokinesia for 30 days and a low-protein diet; 2) control, low-protein diet; 3) hypokinesia for 30 days and a standard diet (18% protein); 4) control, standard diet (18% protein). Hypokinesia was induced by placing the animals in tight individual cages. Histologic and histochemical investigations of tissues from the liver and skeletal muscles made. Measurements: total lipids; RNA; glycogen content; activity of succinic dehydrogenase; acid and alkaline phosphatase and lipase; total protein.

IMMOBILIZATION METHOD: Cage (tight individual)

RESULTS: Groups 1 and 2 had accumulated liver lipids with fatty cysts formation, most were located at the center of the lobes. Liver glycogen content was reduced. RNA content was unchanged. Ultraviolet microscopy showed a decrease in protein content at the center of the lobes. Succinic dehydrogenase and alkaline phosphatase were reduced in liver sections. Liver tissue changes were similar to those obtained on protein-deficient diets. There were no detectable structural and histochemical changes of the livers of animals on a standard 18% protein diet and immobilized. Muscular atrophic and dystrophic changes were observed in immobilized animals. Muscle glycogen content was reduced but there was no evidence of lipid accumulation.

SOURCE: Space Biology and Medicine 4(5): 124-126, 1970

AUTHOR(S): Bykov, G.P. and V.P. Smirnov

EXPERIMENT TITLE: Morphological Changes in Bone and Muscle Tissue During Hypokinesia

SUBJECTS: Rats; Rabbits

AREA OF STUDY: Skeletal; Muscular

OBJECTIVES: In title

PROTOCOL: Three groups: 1) hypokinetic rats - 127 subjects kept in small, confining cages for various periods up to 117 days; 2) immobilized rabbits - 30 subjects, talocalcaneal and knee joints of the right rear leg immobilized by plaster cast, up to 60 days; 3) biopsies of muscle tissue from human subjects afflicted with myasthenia gravis - 11 patients. The distal third of the lower leg and foot was studied in groups 1 and 2; in studying the muscle tissue the quadriceps formis and gastrocnemius muscle were investigated. Measurements: morphological data on condition of bone/muscle structures and fibers; succinate dehydrogenase, cholinesterase, and protein activity; lipid content; histoplanimetric evaluation of the thickness of the bones.

IMMOBILIZATION METHOD: Cage; Cast

RESULTS: Bone tissue: 1) rabbits - the bony walls and outer lamella were considerably thinner than in control. There were particularly well-expressed atrophic changes in the cortical part of the calcaneal tubercle in the region adjacent to the Achilles tendon; 2) rats - no differences were discovered in histological structure; there was, however, a relative decrease in thickness of the lamella of transverse sections of the tibias in rats with a lesser weight. Muscle tissue: 1) rabbits - the muscles decreased in volume and became flabby at the time of autopsy. A clearly expressed atrophy of a considerable number of muscle fibers, both singly and in groups; in many cases there were sinuous fibers with an intensified longitudinal striation; non-uniformity in the thickness and coloring of the fibers; the spaces between the fibers had broadened and were filled with fibrous connective tissue structures and focal lympho- and histocytic infiltrates, increase in number of nuclei in the atrophied fibers. Succinate dehydrogenase decreased; lipid content and cholinesterase activity somewhat reduced; protein content remained unchanged; 2) human subjects: a considerable number of thinned fibers, which had lost their transverse and longitudinal striation, with an increase in the number of nuclei and quantity of pyroninophilic protoplasm; evidences of edema and hydropic dystrophy of the muscle fiber sarcoplasm; glycogenic dystrophy were observed frequently; 3) rats - changes corresponding to manifestations of atrophy and dystrophy were not distinctly expressed; 18 days - unmodified muscle fibers predominated, 30 days - majority unmodified, but more atrophied fibers; with a further increase in duration

no new forms of changes were observed; succinate dehydrogenase activity was non-uniform; cholinesterase and protein did not differ from control; lipid content was reduced at 30 days.

SOURCE: Space Biology and Medicine 4(2): 133-141, 1970

AUTHOR(S): Caraway, B.L.

EXPERIMENT TITLE: Physiologic Baseline Studies of Zoologic Specimens:
Physiologic Values of the Normal Immature Chimpanzee
Under Restraint

SUBJECTS: 8 Immature chimpanzees (9.3-14.2 kg)

AREA OF STUDY: Blood; Endocrine

OBJECTIVES: In title

PROTOCOL: All subjects were kept in a metabolism cage for 1 wk prior to use. During the first 24 hr each animal was completely restrained in a form-fitting couch and hourly recordings of room temperature and humidity, body temperature, respiratory rate, pulse, and blood pressure were made. A 24 hr collection of urine was divided into 4 samples. Urinalysis consisted of specific gravity, 24 hr volume, and assays for creatinine, sodium, potassium, 17-ketosteroids, 17-hydroxycorticosteroids, and total catecholamines. After the 24 hr period the animals were returned to the colony and the blood picture followed for 1 week. Four blood samples were taken at the 0 hr, 24 hr, 48 hr and 92 hr of experimentation. The blood samples were subjected to a total analysis and blood chemistry. Diet: oranges, apples and Purina monkey pellets, supplemented by a fortified milk mixture.

IMMOBILIZATION METHOD: Form-fitting couch

RESULTS: The effects of restraint plotted over an 8 day period depict fluctuations in the hematogram and serum biochemical values. An effort was made to correlate anxiety during restraint with variations in physiologic values. Most of the parameters under study did fluctuate during restraint and subsequently returned to baseline after release from restraint.

SOURCE: School of Aerospace Medicine, Brooks AFB, Texas, December 1966, 37 pp. (SAM-TR-66-100).

AUTHOR(S): Cardenas, D.D., W.C. Stolov, and R. Hardy

EXPERIMENT TITLE: Muscle Fiber Number in Immobilization Atrophy

SUBJECTS: Female Sprague-Dawley rats (213 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Plaster casts were applied to the right limbs up to the groin in such a fashion so as to produce knee flexion and ankle plantar flexion for 4 wk. The soleus muscles from the control and immobilized limbs were excised and frozen after the above period. The techniques used insured that cross sections subsequently cut and stained would contain all the fibers extending from the origin to the aponeuroses. The total number of muscle fibers per muscle was counted from 25 to 50 photomicrographs made for each muscle cross section. For each animal the casted soleus was compared to the normal soleus and the difference in the total number of fibers per muscle subjected to the paired t-test.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: Each of the animals gained weight during the immobilization by 12%. Prior to immobilization full ankle dorsiflexion was 165° from full plantar flexion. By the end of the experimental period the range of motion was reduced to 0 to 87. This result assured that immobilization had been successful. The mean and standard deviation of the total number of fibers per soleus in the normal limbs was 2812 ± 521 . For the casted soleus muscles, the mean and standard deviation was 2930 ± 403 . Using the paired t-test no significant difference was found.

SOURCE: Archives of Physical Medicine and Rehabilitation 58: 423-426, 1977

AUTHOR(S): Castelli, A.

EXPERIMENT TITLE: Effect of Cold and Restriction of Movement on Mast Cells and Metachromasia of Rat Skin

SUBJECTS: Male Wistar rats (260-340 gm)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Three groups: 1) control; 2) and 3) maintained in cages at $12^{\circ}\pm 2^{\circ}\text{C}$ for 2 and 14 days, respectively. The dimensions of the cages permitted the rats to move only with difficulty. The rats were decapitated and full-thickness skin samples were cut from the shaved right flanks. Measurements: intensity of ground substance metachromasia; mast cell density; mast cell types.

IMMOBILIZATION METHOD: Cage (13.75 x 6.25 x 6.25 cm)

RESULTS: The skin, after 14 days of stress, showed many areas containing individually dispersed extracellular metachromatic granules, cells with granules clumped together in irregular and angular shapes as well as areas of the ground substance which failed to stain metachromatically. The highest mast cell density in each of the 3 groups was found in subcutaneous tissue.

SOURCE: Nature 207: 89-90, 1965

AUTHOR(S): Caul, W.F., D.C. Buchanan, and R.C. Hays

EXPERIMENT TITLE: Effects of Unpredictability of Shock on Incidence of Gastric Lesions and Heart Rate in Immobilized Rats

SUBJECTS: 60 Male Holtzman rats

AREA OF STUDY: Digestive; Circulatory

OBJECTIVES: In title

PROTOCOL: Restraint: 19 hr. The immobilization device restrained the rat by securing the legs in grooves appropriately placed in a Plexiglas base and fitted with leg stops and clamps. Groups: during immobilization 1) received conditioned stimulus (CS; 12-sec pulsating, 80 db, 1 kHz tone); 2) 50% of CS presentations were paired with an unconditioned stimulus (UCS; 3.5 ma shock); 3) all CS presentations paired with the UCS; 4) 50% CS-UCS pairings with the number of UCS presentations equal to group 3; or 5) unrelated presentations of the CS and UCS. Measurements: gastric ulceration; heart rate.

IMMOBILIZATION METHOD: Leg stops and clamps

RESULTS: The unpredictability of group 5 presentations produced significantly greater ulceration than in group 1 with all other groups falling between these extremes. While groups 2, 3 and 4 showed reliable and equivalent bradycardiac responses to the CS, the pre-CS heart rate measure failed to discriminate among groups.

SOURCE: Physiology and Behavior 8: 669-672, 1972

AUTHOR(S): Chayvialle, J.A., R. Lambert, and D. Ruet

EXPERIMENT TITLE: The Effects of Restraint on Uptake of Radioactive Sulfate in the Salivary and Gastric Secretions of Rats with Pyloric Ligation

SUBJECTS: 102 Wistar rats

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Four groups: all rats received 100 μ C of 35 Sulfur ip prior to restraint: 1) gastric secretion collected after pyloric ligation or after pyloric and esophageal ligation; 2) ligature placed between the rumen and glandular stomach; 3) catheter maintained in the abdominal esophagus by a ligature and connected to a intraperitoneal small balloon; 4) controls, nonrestrained. Rats were immobilized in a metallic tube for 6 hr then sacrificed with ether. Gastric secretions, saliva, contents of stomach and gastric glandular wall were analyzed. Measurements: non-dialysable radioactive sulfate after peptic proteolysis.

IMMOBILIZATION METHOD: Metallic tube

RESULTS: During 6 hr restraint there was a significant decrease in salivary radioactive sulfate which was responsible for the decrease of sulfate in the gastric contents of rats with pyloric ligation. Esophageal ligation associated with this prevented the passage of saliva and lowered the amount of radioactive sulfate in the gastric juice. Restraint caused an increase in the amount of sulfate in the gastric juice, significantly lower than in rats with a free esophagus. No significant changes were found in the gastric wall.

SOURCE: Comptes Rendus des Seances de la Societe de Biologie et de ses Filiales 168(1): 114-118, 1978

AUTHOR(S): Chernov, I.P.

EXPERIMENT TITLE: Change in Radiosensitivity of Rats During Hypokinetic Stress

SUBJECTS: 300 Male rats (150-170 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Hypokinesia was produced by placing the animals in organic glass restraining cages. The rats were irradiated with a dose of 800 rad with γ -quanta Co^{60} . Four groups: 1) irradiation on 3rd day of hypokinesia; 2) irradiation on 20th day of hypokinesia; 3) irradiation on 3rd day of restoration after 20 days of hypokinesia; 4) controls were only exposed to hypokinesia or radiation. The animals in the experimental and control groups were killed by decapitation 1, 3, 10, 30 and 45 days after irradiation. For 6 rats from each period a recording was made of the body weight, weight of hypophysis, adrenals, spleen, heart, and testicles.

IMMOBILIZATION METHOD: Cage (organic glass)

RESULTS: The most pronounced reaction to radiation occurred in the 1st group. Irradiation on the 3rd day of hypokinesia increased the sensitivity of the animals to the radiation which manifested itself in early death, earlier and more significant weight loss of the body, spleen, and testicles. An increase in resistance to radiation was seen on the 20th day of hypokinesia.

SOURCE: Radiobiologia No.4: 574-578, 1978

AUTHOR(S): Chernyy, A.V.

EXPERIMENT TITLE: Glycemic Indices of Animals at Different Times During Hypokinesia With the Injection of Glucose, Adrenaline and Insulin

SUBJECTS: 68 Male white rats (180-230 gm)

AREA OF STUDY: Blood; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) experimental; 2) control. The animals in the experimental groups were placed for immobilization in individual close cages. There were 3 series of experiments. Rats were injected with the following substances on the 15th, 30th, 60th and 90th days of hypokinesia: series 1 - glucose (4 g/kg); series 2 - adrenaline (150 mg/kg); and series 3 - insulin (0.5 unit/kg). Diet: morning - beets and grain; evening - oats or sunflower seeds, milk or meat and unrestricted water. Measurements: blood sugar after administration of substances.

IMMOBILIZATION METHOD: Cage (small plastic)

RESULTS: Hypokinesia caused an increased sensitivity to insulin, an elevated tolerance to glucose, and a less distinct response to adrenaline.

SOURCE: Space Biology and Medicine 9(1): 35-42, 1975

AUTHOR(S): Chiroff, R.T. and J. Jowsey

EXPERIMENT TITLE: The Effect of Calcitonin on Immobilization Osteopenia

SUBJECTS: Mongrel female puppies, 6-7 mo old

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Immobilization: 6 subjects, 8 wk, plaster-of-Paris spica cast applied to left hind limb in flexion. Two groups (3 subjects each): 1) porcine calcitonin, 12 MRC units per mg, administered subcutaneously in a 16% gelatin suspension every 8 hr; 2) injections of gelatin carrier only. Each animal was also given tetracycline preparations. Diet: routine. Measurements: bone weight (femora and second metatarsal); serum calcium and phosphate levels; site/rate of bone formation; bone resorption; microradiography (tibiae).

IMMOBILIZATION METHOD: Cast

RESULTS: Roentgenograms of both hind limbs showed a loss of cortical thickness of the bones of the immobilized limb after 6 wk in both the treated and the control groups. Roentgenographic evidence of osteopenia was clear-cut after 8 wk; the bones of the treated and control animals showed an apparent loss of mineral density, a decrease in cortical thickness, and a loss of trabecular patterning of the cancellous bone. Significant hypocalcemia and hypophosphatemia were produced in the calcitonin-treated animals. The fall in the serum calcium and phosphate was significantly less after 8 wk of immobilization than it was at both the start of the study and after 4 wk. Both the calcitonin-treated and control animals showed a significantly lower dry, fat-free weight of the femora and second metatarsal bones. Bone formation rates (calculated by measuring the distance between fluorescent bands) were normal and of the same magnitude in each animal throughout the study. Quantitative microradiography of the cortical bone of the mid-tibiae revealed that bone formation increased slightly in the immobilized tibiae of both groups when compared with the normal limb. The increase seen was not significant when the values for all animals in each group were taken together; individually, bone formation was increased in the immobilized limb in all animals. Bone resorption showed a significant increase in the immobilized tibiae both for the calcitonin-treated and control groups.

SOURCE: Journal of Bone and Joint Surgery 52A(6): 1138-1146, 1970

AUTHOR(S): Chor, H. and R.E. Dolkart

EXPERIMENT TITLE: A study of "Simple Disuse Atrophy" in the Monkey

SUBJECTS: 6 Young macacus rhesus monkeys

AREA OF STUDY: Muscular

OBJECTIVES: To further clarify the problem of simple disuse atrophy of skeletal muscles.

PROTOCOL: A body and leg cast was applied in order to reduce the activity of the gastrocnemius-soleus muscles; the limb was held in a position of slight flexion at the knee. At designated periods of 1, 2, 3, 4, 6 and 10 wk, the casts were removed and the gastrocnemius-soleus muscles were dissected. Measurements: weight of muscle groups; also, histologic studies and chemical analyses (water, nitrogen and protein content).

IMMOBILIZATION METHOD: Plaster cast

RESULTS: There was a decrease of muscle bulk, especially of the sarco-plasm (loss of 4.9%, as compared with control), within 1 wk after immobilization; atrophy increased with a greater duration of inactivity. The proportions of water, protein and nitrogen remained essentially the same as in normal muscle.

SOURCE: American Journal of Physiology 117: 626-630, 1936

AUTHOR(S): Cockett, A.T.K., A. Elbadawi, R. Zemjanis, and W.R. Adey

EXPERIMENT TITLE: The Effects of Immobilization on Spermatogenesis in Subhuman Primates

SUBJECTS: Male monkeys (Macaca nemestrina) (5.4-6.75 kg)

AREA OF STUDY: Reproduction

OBJECTIVES: In title

PROTOCOL: Animals were electroejaculated 13, 20, 30 and 60 days prior to orbital flight for 8½ days plus ground restraint or simulated flight conditions of restraint in the flight couch for 15-40 days. Testicular biopsy was performed 13 days before immobilization and after immobilization. One animal was placed into orbital flight after 13 days of ground restraint. Measurement: testicular sections.

IMMOBILIZATION METHOD: Couch

RESULTS: After 26 days of immobilization there was severe testicular degeneration. All tubules were lined by a single or double layer of normal Sertoli cells. The biopsy of the animal which was in orbital flight following restraint showed similar changes.

SOURCE: Fertility and Sterility 21: 610-614, 1970

AUTHOR(S): Cockett, A.T.K., R. Zemjanis, A. Elbadawi, and W.R. Adey

EXPERIMENT TITLE: Male Infertility: Histochemical Changes in the
Subhuman Primate Testes after Prolonged Immobilization

SUBJECTS: Male Macaca nemestrina monkeys (5.4-7.2 kg)

AREA OF STUDY: Reproduction

OBJECTIVES: In title

PROTOCOL: Immobilization: 14 days in a special NASA holding or restraint chair. Testicular biopsies were obtained before and immediately after immobilization. Diet: Purina monkey chow ad libitum and fresh fruits. Measurements: lactic dehydrogenase; succinic dehydrogenase; alkaline phosphatase.

IMMOBILIZATION METHOD: Chair

RESULTS: Immobilization resulted in spermatogenic arrest in the seminiferous tubules. Enzymatic changes included lactic dehydrogenase, succinic dehydrogenase, and alkaline phosphatase. Diffusion and dumping of enzymatic activity noted. Histologic alterations were also demonstrated.

SOURCE: Fertility and Sterility 22: 565-572, 1971

AUTHOR(S): Cogger, E.A., R.E. Otis, and R.K. Ringer

EXPERIMENT TITLE: Heart Rates in Restrained and Freely-Moving
Japanese Quail Via Radio Telemetry

SUBJECTS: 20 Japanese quail (*Coturnix coturnix japonica*)
(21-30 wk old; males, 106 ± 5.7 gm; females, 132 ± 15.6 gm)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) restraint for 17.5 min; 2) freely moving. Quail were restrained on their backs by tying their beaks, wings, and feet down to a flat board. Measurements: heart rate - by use of radio telemetry.

IMMOBILIZATION METHOD: Tied to flat board

RESULTS: When freely moving, quail had mean heart rates of 360 ± 14.6 beats per min (bpm); immediately postrestraint heart rates significantly increased to 455 ± 22.2 bpm; and during the 30-min postrestraint, heart rates decreased to 436 ± 17.9 bpm which was significantly lower than immediately postrestraint and higher than in the freely moving condition. No sex effect on heart rate was seen.

SOURCE: Poultry Science 53: 430-431, 1974

AUTHOR(S): Conaway, H.H., L.C. Waite, and A.D. Kenny

EXPERIMENT TITLE: Immobilization and Bone Mass in Rats: Effects of Parathyroidectomy and Acetazolamide

SUBJECTS: Male and female rats (200-250 gm)

AREA OF STUDY: Skeletal; Pharmacology

OBJECTIVES: In title

PROTOCOL: One forelimb was denervated by section of the brachial nerve plexus. Rats were parathyroidectomized (in 2 experiments, males were fed pelleted chow ad libitum; in the 3rd experiment, females were pair-fed ground chow) or given a diet containing 0.5% acetazolamide sodium at time of denervation (in 1 experiment rats were fed ground chow ad libitum; in 2 experiments rats were pair-fed ground chow). Bones were removed 10-14 days after denervation. Diet: commercial chow-pelleted and ground. Measurements: body weight; dry bone weight; plasma calcium levels.

IMMOBILIZATION METHOD: Denervation

RESULTS: Parathyroidectomy inhibited the development of the denervation response 45%, 30%, and 85% in 3 experiments, as did acetazolamide, 42%, 47%, and 64%. Under pair-feeding conditions, acetazolamide caused slight but significant hypercalcemia.

SOURCE: Calcified Tissue Research 11: 323-330, 1973

AUTHOR(S): Cooper, D.O. and J.M. Stolk

EXPERIMENT TITLE: Differences in the Response of Superior Cervical Ganglion Dopamine- β -Hydroxylase Activity to Immobilization Stress Between Inbred Rat Strains

SUBJECTS: Male rats, 3 inbred strains (LEW, WF, and F344)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Immobilization: rats were immobilized in a prone position by inserting their heads through wire loops fixed on a metal plate and fastening their limbs to specially mounted metal strips with adhesive tape. Two groups: 1) daily 1 hr immobilization sessions, 6 days, dopamine- β -hydroxylase (DBH) activity in superior cervical ganglion (SCG) tissue measured 24 hr later; 2) single 1 hr immobilization session, SCG DBH activity measured immediately. SCG supernates were diluted 1:6 with distilled water for all experiments. Subjects had free access to food and water for 28 days prior to the start of the experiment. Measurement: SCG DBH activity.

IMMOBILIZATION METHOD: Wire loops, metal plate and strips, and tape

RESULTS: Group 1) major qualitative differences were found between strains: 2 strains (F344 and WF) evidenced increased enzyme activity (25% and 32%, respectively); the LEW strain revealed a 25% lower SCG DBH activity following immobilization. Group 2) significant changes were found in SCG enzyme activity for all 3 strains: LEW, 15% increase, F344, 77% increase; WF, increase intermediate to that observed in the other two strains.

SOURCE: Communications in Psychopharmacology 1(3): 291-299, 1977

AUTHOR(S): Cooper, R.R.

EXPERIMENT TITLE: Alterations During Immobilization and Regeneration of Skeletal Muscle in Cats

SUBJECTS: Adult cats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Four groups: 1) 5 controls; 2) 6 cats, plaster cast applied from paw to hip on 1 hind leg in rest length position for 2, 4, 6, 8, 14 and 22 wk; 3) 6 cats, restrained in casts for 10 wk and then the muscles examined 1, 2, 3, 4 and 6 wk after cast removal; 4) 5 cats, 5 cm segment of sciatic nerve was removed and their muscles examined 2, 4, 6, 8 and 18 wk later. The contralateral non-immobilized limbs of the cats also served as controls. Measurements: muscle weight changes; electrical and mechanical properties of muscles; intracellular regeneration of muscle.

IMMOBILIZATION METHOD: Plaster cast; Denervation

RESULTS: The muscles of all experimental groups lost an increasing amount of weight during immobilization. The soleus lost weight more rapidly than the flexor digitorum longus and gastrocnemius. After release, muscle weights gradually increased but in 6 wk did not equal that of the contralateral side. The average contraction time and relaxation time increased somewhat in the immobilized muscles; muscles returned to normal within 1 wk after release from immobility. Immobilized muscle fibers underwent a more or less well defined sequence of degenerative changes in which many fibers remained simply as sarcotubules which contained only fluid, precipitated protein, and fragments of the sarcolemma.

SOURCE: Journal of Bone and Joint Surgery 54A: 919-953, 1972

AUTHOR(S): Corley, K.C., F.O'M. Shiel, M.R.C. Path, H.P. Mauck, and J. Greenhoot

EXPERIMENT TITLE: Electrocardiographic and Cardiac Morphological Changes Associated with Environmental Stress in Squirrel Monkeys

SUBJECTS: 19 Adult squirrel monkeys

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Monkeys were restrained and trained in Sidman avoidance of electrical tail shock; following training they were exposed 8 hr on/8 hr off avoidance with food and water provided every 24 hr. All monkeys were killed after stress. Measurements: EKG. The heart, stomach and adrenals were examined grossly and microscopically for pathological changes.

IMMOBILIZATION METHOD: Not stated

RESULTS: During stress, the EKG showed an initial tachycardia followed after the 1st hr by heart rate slowing. Progressive bradycardia occurred in the EKG of several monkeys, accompanied by a spectrum of arrhythmias. No gastric lesions occurred, coronary arteries were patent, and adrenal tissue was normal. Hearts appeared normal but microscopic examination showed lesions. Fibrosis was found.

SOURCE: Psychosomatic Medicine 35: 361-364, 1973

AUTHOR(S): Corrodi, H., K. Fuxe, and T. Hokfelt

EXPERIMENT TITLE: The Effect of Immobilization Stress on the Activity of Central Monoamine Neurons

SUBJECTS: 250 Male Sprague-Dawley rats (150-250 gm)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: The rats were immobilized by placing them in small wire cages and attaching their legs to the metal wires which build up the cage. Various inhibitor drugs were administered before or after immobilization: Group 1) received the methylester of α -methyltyrosine (H 44/68) immediately before immobilization and 4 and 8 hr before killing. Group 2) received α -propyl dopacetamide (H 22/54) immediately before immobilization and 3 hr before killing. Group 3) received p-chloro-phenylalanine methylester hydrochloride (H 69/17) 16 hr before killing; animals were kept immobilized for 16 hr due to slow onset of decrease of 5-HT. Groups 4&5) not exposed to stress and treated with H 44/68, H 22/54 and H 69/17. The non-pooled brains of half of the rats in each group were taken for histochemical analysis and the rest to chemical analysis of the monoamines. Measurements: dopamine (DA); noradrenaline (NA); 5-hydroxytryptamine (5-HT).

IMMOBILIZATION METHOD: Cage (small wire)

RESULTS: With immobilization, slight decreases occurred in DA, NA, and 5-HT of the brain and spinal cord. The decreases in 5-HT were significant after 3 hr but not 16 hr. Depletion of NA was accelerated after 4 hr of immobilization but changes in DA were not certain. Histochemically, amine depletion was evident in practically all of the various NA nerve terminals of the brain and spinal cord of skeletal rats. 5-HT changes did not occur.

SOURCE: Life Sciences 7(1, Pt. 1): 107-112, 1968

AUTHOR(S): Cragg, B.G.

EXPERIMENT TITLE: The Role of the Habenula in the Respiratory Response
of the Rabbit to Warmth or to Restraint

SUBJECTS: Rabbits

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Three groups: 1) negative square wave stimulating pulses (electrical stimulation) were applied to the habenular, interpeduncular and dorsal tegmental nuclei; 2) local heating was applied to the preoptic area by passing a current through a heating element 1 mm long and 400 μ in diameter; 3) intact, restrained in a 15 x 15 x 30 cm wooden box. In some rabbits, bilateral section of the stria medullaris was performed prior to a 2nd restraint. Measurements: respiration rate; blood pressure, knee jerk force elicited by a blow; pressure in urinary bladder. The stria medullaris was then sectioned.

IMMOBILIZATION METHOD: Wooden box (15 x 15 x 30 cm)

RESULTS: Electrical stimulation to the habenular, interpeduncular and dorsal tegmental nuclei caused panting, cutaneous vascular dilation and somatic muscular relaxation. Prolonged stimulation resulted in lowered rectal temperature. Stimulation of the preoptic area and the medial forebrain bundle also caused panting. Local heating in both the diagonal band and in the substantia innominata caused panting. These responses were not abolished by section of the stria medullaris. Restraint caused panting in 29 of 31 rabbits tested; complete bilateral section of the stria or interruption of the habenulointerpeduncular tract abolished the panting response.

SOURCE: Experimental Neurology 4: 115-133, 1961

AUTHOR(S): Crawford, G.N.C.

EXPERIMENT TITLE: The Growth of Striated Muscle Immobilized in Extension

SUBJECTS: 23 Rabbits, 3-4 wk old

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: One hind limb of the rabbits was maintained in full plantar-flexion by insertion of a rigid metal wire into the metatarsus and tarsus and through the marrow cavity of the tibia and extended 2/3 up the shaft of the tibia and cut off distally at the level of the distal end of the metatarsus. The contralateral limb served as the control. Rabbits were kept until full grown. The rabbits were divided into 4 groups according to the degree of immobilization: 1) complete immobilization, 8 rabbits; 2) partial immobilization (muscle excursion of 5-10 mm), 5 rabbits; 3) partial immobilization (muscle excursion of 10-20 mm), 6 rabbits; 4) full movement restored, 4 rabbits. Measurements: tibialis anterior muscles and tendons, their tension-length curves, and muscle fibers.

IMMOBILIZATION METHOD: Internal fixation with metal wire

RESULTS: Muscles which remained immobilized or whose movement was partially restored grew to a length of 80-90% of controls when measured in plantar-flexion. The former was the same as controls when both were exerting their maximum developed tension; the latter were a little shorter. Muscle fasciculi of the immobilized muscle were 50% and in controls 70% of the length of their respective bellies. Immobilized fasciculi were 70% of the length of controls when exerting maximum developed tension. The length of the sarcomeres of the completely immobilized muscles were 80% of the controls or partially mobile muscles. The tension exerted by the immobilized muscles was greater than normal, there was an increase in the cross-sectional area of their fasciculi. Muscles whose movement was restored did not differ from the controls.

SOURCE: Journal of Anatomy 114(2): 165-183, 1973

AUTHOR(S): Crelin, E.S. and W.O. Southwick

EXPERIMENT TITLE: Changes Induced by Sustained Pressure in the Knee
Joint Articular Cartilage of Adult Rabbits

SUBJECTS: Rabbit, New Zealand strain, 6-7 mo (3.5-4.0 kg)

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Fixation: right knees of 26 rabbits, fixed with metal clamps midway between full flexion and full extension. Two groups: 1) 3 males and 3 females, 6 days, after which the animals were sacrificed and the knees excised and preserved in 10% formalin while clamped; 2) 10 males and 10 females, 5 of each sex received 5 mg colchicine in saline ip on the 8th, 11th and 15th days following application of the clamps. All subjects were sacrificed on the 16th day and the knees preserved. Measurements: gross and microscopic evaluation of changes in knee joint articular cartilage.

IMMOBILIZATION METHOD: Clamp

RESULTS: The femoral and tibial articular cartilages subjected to pressure for 6 days were extremely compressed but viable. The degree of flattening appeared to be the same in both the medial and lateral femoral and tibial condyles. The region of maximum compression was localized just beyond the free edge of the menisci. In knees clamped for 16 days the changes found were related to the amount of knee movement present at autopsy. Where it was small but easily detectable the cartilages were normal; where there was no movement the cartilage was dead. Where it was only slightly variable cartilage changes were found, ranging from surface abrasion, matrix swelling, enlargement of the lacunae and chondrocytes, increased number of cells per lacuna, and an occasional chondrocyte in mitosis, to an extensive matrix alteration resulting in the disappearance of lacunae, chondrocytes released from the confines of lacunae and interspersed among a meshwork of fine collagen fibers, and a few released chondrocytes in mitosis. The most extensive change was where the cartilage defect area was occupied by a mass of proliferating richly-cellular tissue.

SOURCE: Anatomical Record 149: 113-134, 1964

AUTHOR(S): Crockett, J.L. and V.R. Edgerton

EXPERIMENT TITLE: Exercise and Restricted Activity Effects on
Reinnervated and Cross-Innervated Skeletal
Muscles

SUBJECTS: 18 Male Hartley guinea pigs (250-300 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Prerestrain: all animals had the slow-twitch soleus and fast-twitch flexor hallucis longus muscle nerves cut in the left leg and cross-innervated; in the contralateral leg, the same muscle nerves were cut and self-innervated. The hind limbs of all animals were put in plaster casts immediately postoperatively. For groups 1 and 3, the casts remained in situ for 1 wk; group 2, 1 mo. Groups 1 and 2 remained in cages for 6 mo; group 3 was exercised 3 days/wk. Measurements: histochemistry; biochemistry.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: Reinnervation of the muscles was complete with either the original nerve or with a foreign nerve after 6 mo in all groups of animals regardless of whether the animals were exercised or confined to cages. Hind-limb restraint, whether 1 wk or 6 mo, did not alter the extent and efficiency of reinnervation, muscle protein concentration fell in 1-mo restrained animals, and the cross-innervation procedures resulted in the histochemical fiber populations correlating closely with the physiologically determined muscle contraction time.

SOURCE: Journal of Neurological Sciences 25(1): 1-10, 1975

AUTHOR(S): Curzon, G. and A.R. Green

EXPERIMENT TITLE: Effects of Immobilization on Rat Liver Tryptophan
Pyrrolase and Brain 5-Hydroxytryptamine Metabolism

SUBJECTS: Male Sprague-Dawley rats (180-230 gm)

AREA OF STUDY: Metabolism and Energy Exchange; Pharmacology

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats were immobilized for 8 hr by putting their legs through a wire grid and fastening them with adhesive tape. Some experimental animals received the following drugs prior to immobilization: LSD, allopurinol, probenecid and α -methyltryptophan, and chlorpromazine. At the termination of the experiment, the activity of 5-HT and 5-HIAA in the brain and liver tryptophan pyrrolase were determined. The effect of immobilization and allopurinol on the above indices was also studied on adrenalectomized rats.

IMMOBILIZATION METHOD: Wire grid and adhesive tape

RESULTS: Immobilization caused a decreased brain 5-hydroxytryptamine synthesis resulting from pyrrolase induction and increased 5-hydroxytryptamine breakdown by a more direct effect on the brain. Results of experiments on rats injected with LSD, and with α -methyltryptophan or probenecid were consistent with that interpretation. The 5-HT and 5-HIAA changes were maximal after 5-6 hr of immobilization and became less on more prolonged immobilization. Rat liver tryptophan pyrrolase increased on immobilization. Immobilized adrenalectomized animals' pyrrolase activity did not change and brain 5-HT fell slightly but the 5-HIAA concentration rose.

SOURCE: British Journal of Pharmacology 37: 689-697, 1969

AUTHOR(S): Curzon, G. and A.R. Green

EXPERIMENT TITLE: Regional and Subcellular Changes in the Concentration of 5-Hydroxytryptamine and 5-Hydroxyindoleacetic Acid in the Rat Brain Caused By Hydrocortisone, DL- α - Methyl-Tryptophan L-Kynurenine and Immobilization

SUBJECTS: Adult male Sprague-Dawley rats (180-220 gm)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: The following drugs were dissolved in 0.9% w/v sodium chloride solution and injected ip in a volume of 5 ml/kg: hydrocortisone sodium succinate, DL- α -methyltryptophan, and L-kynurenine sulphate. After various periods of immobilization (1-5 hr), rats were stunned by a blow across the back of the neck while still immobilized, and decapitated. Rats were immobilized by putting their legs through holes in wire grid and adhesive taping front and back pairs of legs together. Diet: Oxo 41B pellets ad libitum; tap water ad libitum. Measurements: 5-hydroxytryptamine (5-HT); 5-hydroxyindoleacetic acid (5-HIAA); hypothalamus; particulate and supernatant fractions.

IMMOBILIZATION METHOD: Wire grid and adhesive tape

RESULTS: All drugs decreased 5-HT and 5-HIAA concentrations in different regions of the brain. 5-HIAA changes after hydrocortisone corresponded significantly to those after α -methyltryptophan in a previous study; 5-HT changes did not correspond. L-kynurenine caused larger decreases in 5-HT than in 5-HIAA. 5-hr immobilization decreased 5-HT and increased 5-HIAA in most brain regions. In decreasing order, the percentage decreases of 5-HIAA 6-hr posthydrocortisone injection were: hypothalamus, striatum, cerebellum, midbrain, pons plus medulla and cortex; after 5-hr immobilization, the percentage increases were in reverse order. The differences between percentage decreases in 5-HIAA after hydrocortisone and postimmobilization were very similar in all regions except the hypothalamus. During the first 3 hr of immobilization, 5-HIAA in the hypothalamus and in the rest of the brain increased in parallel fashion; between 3-5 hr, 5-HIAA returned to control values in the hypothalamus, but continued to rise in the rest of the brain. 5-HT changes in the particulate and supernatant fractions after various treatments were comparable except 2 hr after L-kynurenine injection when 5-HT fell in the particulate but not in the supernatant.

SOURCE: British Journal of Pharmacology 43: 39-52, 1971

AUTHOR(S): Curzon, G., M.H. Joseph, and P.J. Knott

EXPERIMENT TITLE: Effects of Immobilization and Food Deprivation on Rat Brain Tryptophan Metabolism

SUBJECTS: Adult male Sprague-Dawley rats (180-220 gm)

AREA OF STUDY: Nervous; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Three groups of 10-18: 1) controls; 2) food deprived for 3 hr; 3) immobilized for 3 hr. The animals were immobilized by placing their legs through holes in wire grid and adhesive taping of front and back pairs of legs together. Some rats were adrenalectomized. Rats were decapitated and their brains frozen. Diet: Oxo 41B pellets ad libitum; tap water ad libitum. Measurements: tryptophan; tyrosine; liver pyrrolase activity; brain weight; 5-hydroxytryptamine (5-HT); 5-hydroxyindoleacetic acid (5-HIAA).

IMMOBILIZATION METHOD: Wire grid and adhesive tape

RESULTS: Both food deprivation and immobilization changed brain tryptophan metabolism; the results were consistent with regression lines from their respective control groups. Brain tryptophan and 5-HIAA concentration increased; 5-HT increases were much smaller. Changes were greater under food deprivation. Brain tyrosine concentration increased slightly under deprivation, and significantly decreased under immobilization. Plasma tryptophan did not increase. Adrenalectomy did not abolish brain indole metabolism changes.

SOURCE: Journal of Neurochemistry 19: 1967-1974, 1972

AUTHOR(S): Demeterova, M. and R. Skarda

EXPERIMENT TITLE: The Morphological Picture of Neurosecretive Cells of the Nucleus Supraopticus and Paraventricularis in Chickens With Long-Term Hypokinesia

SUBJECTS: 20 Ross roosters, 14 days old (220 gm)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Four groups: 1) hypokinesia in cages for 14 days, 4 chickens; 2) hypokinesia for 28 days, 5 chickens; 3) hypokinesia for 42 days, 5 chickens; 4) 6 controls. The chickens were placed in cages that were designed in such a way that they could not move freely or even turn around. After decapitation of the chickens and the opening of their cranial cavities, the brains were removed and fixed in a 4% solution of neutral Formalin for a period of 1 wk. Performed serial frontal paraffin cuts on the hypothalamus and stained them with hematoxylineosin. Diet: water and food ad libitum. Measurements: vertical cross sections; sizes of cell nuclei in nucleus supraopticus and paraventricularis.

IMMOBILIZATION METHOD: Cage

RESULTS: The morphological picture of the nucleus supraopticus cells in all three test groups remained unchanged when compared with the control group. There was a slight decrease in the size of the cell nuclei, the difference from the control group was statistically insignificant. The nucleus paraventricularis cells responded to the long-term hypokinetic stress by a change in functional activity while the morphological picture of the cells after 42 days of hypokinesia approached the control. After 28 days there appeared a statistically significant reduction in the size of the cell nuclei. It appeared that the nucleus paraventricularis cells took a longer time to adapt themselves to the hypokinetic condition or their reaction was slower than in the nucleus supraopticus and the changes in the morphological picture in this period were more significant.

SOURCE: Veterinari Medicina 22(11): 679-686, 1977

AUTHOR(S): Denisenko, P.P. and A.N. Poskalenko

EXPERIMENT TITLE: Participation of Thyroid Gland Hormones in the Mechanism of Development of Trophic Disturbances of the Gastric Mucosa in Rats Resulting From Their Prolonged Immobilization

SUBJECTS: 130 Male rats (150-160 gm)

AREA OF STUDY: Digestive; Endocrine; Pharmacology

OBJECTIVES: In title

PROTOCOL: Immobilization: 24 hr. The rats were immobilized by tying their paws to a bench. Group 1 consisted of 38 controls. The experimental animals were divided into 5 groups of 10-18 rats each. Experimental conditions: groups 2) administered 0.2 gm thyroindin daily for 3 days; 3) thyroid glands removed 5 days before the experiment; 4) administered 0.05 gm methythyouracil orally daily for 3 days; 5) administered 0.2 gm thyroindin ip daily and 10 mg/kg hexonium twice a day for 3 days before immobilization; 6) administered 5 mg/kg metamytil ip 3 times. After immobilization the animals were decapitated, the abdominal cavity was opened, and the stomach was examined. The condition of the gastric vascular network, and the size, filling, and tonus of the walls were evaluated. Incision was made in the stomach and the number and dimensions of lesions were calculated. The stomachs of 2-5 rats were investigated histologically.

IMMOBILIZATION METHOD: Bench

RESULTS: Immobilization caused destructive lesions of the gastric wall. After preliminary thyroidectomy there was a manifold decrease in the number of lesions. Thyroindin sharply increased the tonus and caused an increase in the number of lesions. Metamytil and hexonium reduced dystrophic disturbances by one-half or even more.

SOURCE: Patologicheskaja Fiziologija i Eksperimentalnaja Terapija
11: 30-32, 1967

AUTHOR(S): Di Giovanni, C. and E. DeSantis

EXPERIMENT TITLE: Effects of Immobilization on Articular Cartilage:
Autohistoradiographic Findings with S^{35}

SUBJECTS: Rabbits, New Zealand strain

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Four groups of four rabbits each, for periods of 30, 60, 90 and 120 days. Knee joint immobilized by plaster cast in a position midway between flexion and extension. Contralateral limb served as control. Radioactive sodium sulfate ($Na_2S^{35}O_4$) was injected ip (1 millicurie per kg of body wt). Rabbits were sacrificed 24, 48 and 72 hr after administration of the isotope, and histological sections were obtained. Measurements: degenerative changes in the articular cartilage (light microscope); fixation of S^{35} .

IMMOBILIZATION METHOD: Plaster cast

RESULTS: Degenerative changes in the articular cartilage were observed in an increasing severity over the course of immobilization. The epiphyseal cartilage was one of the first structures effected by lack of movement. Immobilization caused a reduction of S^{35} uptake in all layers of the articular cartilage; the fixation of S^{35} was decreased in advanced immobilization. This phenomenon was most evident in the intermediate and deep layers.

SOURCE: Archivio Putti de Chirurgia degli Organi di Movimento 28: 23-47, 1977

AUTHOR(S): Dinu, M., A. Sneer, S. Dolinescu, M. Mihaila, and E. Dughir

EXPERIMENT TITLE: Morphofunctional Correlations in Experimental Myocardio-pathies During Stress due to Forced Immobilization. Part I

SUBJECTS: White rats (175 gm)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls; 2) starved for 44 hr and deprived of water for 22 hr; 3) immobilized on a board with paws attached to brackets for 24 hr and at the same time deprived of food and water. Measurements made before, immediately after, and 72 hr after experiment: ECGs; mucopolysaccharides; glycogen; SDH; acid phosphatase; glycemia; acid phosphatase; acid cathepsin; glycogen; AVM.

IMMOBILIZATION METHOD: Board

RESULTS: Restraint produced general metabolic and myocardial alterations, in most cases causing microinfarcts, localized especially in the subepicardiac region of the left ventricle. These were revealed on the ECG by the early onset of rhythm and conduction disturbances and especially end phase changes. The biochemical tests after starvation, and especially after immobilization, showed a decrease of glucose, an increase of acid phosphatase and cathepsin in the blood, a decrease of glycogen but an increase of phosphatase and acid cathepsin in the myocardium, and an increase of AVM in the urine. After 72 hr, the changes returned to normal in most cases.

SOURCE: Revista Medico-Chirurgicala a Societatii de Medici si Naturalisti din Iasi 81(3): 431-434, 1977

AUTHOR(S): Dinu, M., S. Dolinescu, A. Sneer, M. Mihaila, and E. Dughir

EXPERIMENT TITLE: Morphofunctional Correlations in the Experimental Study of Myocardiopathies Under the Stress of Forced Restraint. Note II. The Influence of Adrenal Imbalance

SUBJECTS: 70 Male rats (160 gm)

AREA OF STUDY: Circulatory; Endocrine

OBJECTIVES: In title

PROTOCOL: Four groups: 1) controls; 2) unilateral adrenalectomy; 3) bilateral adrenalectomy; 4) 3 hydrocortisone injections (5 mg/100 gm) before restraint. Each group included the following conditions: normal feeding; fasting and thirsting for 44 hr; fasting, thirsting and restraint for 24 + 72 hr. Measurements: mortality rate; glycemia; urinary 17-CS, 17-OH, Na and K ions, P and Mg; EKGs, morphology and histochemistry of myocardium and adrenal glands.

IMMOBILIZATION METHOD: Not stated

RESULTS: The highest mortality rate was in restrained animals subjected to bilateral adrenalectomy (75%). Elimination of K, P and Mg was higher in animals with endocrine imbalance, especially those treated with hydrocortisone. Glycemia decreased in animals with unilateral adrenalectomy after fasting and restraint; increased in those treated with hydrocortisone and those with bilateral adrenalectomy. 17-CS decreased after adrenalectomy and increased after fasting. ECG of operated animals showed a decrease in the amplitude of T waves. After fasting the myocardium showed protein dystrophy and fuchsino-philic reaction of the myocardial fiber; associated restraint increased the zones of micronecrosis in all the groups.

SOURCE: Revista Medico-Chirurgicala a Societatii de Medici si Naturalisti din Iasi No. 1: 87-91, 1978

AUTHOR(S): Djahanguiri, B., H.L. Taubin and L. Landsberg

EXPERIMENT TITLE: Increased Sympathetic Activity in the Pathogenesis of Restraint Ulcer in Rats

SUBJECTS: Female Sprague-Dawley rats (120 gm)

AREA OF STUDY: Digestive; Pharmacology

OBJECTIVES: In title

PROTOCOL: Rats were fasted for 24 hr prior to immobilization. The animals were restrained in fine wire mesh for: 1) 10 hr at normal room temperature (25°C); or 2) 2 hr at 4°C. Animals were killed by a blow at the base of the skull and the organs were quickly removed. The effect of pretreatment with α -methyldopa, bretylium tosylate, phentolamine hydrochloride and phenoxy benzamine hydrochloride was studied, along with adrenalectomy and 6-hydroxydopamine hydrobromide. Diet: Purina Rat Chow; water ad libitum. Measurements: incidence of ulceration; norepinephrine (NE) turnover rate.

IMMOBILIZATION METHOD: Fine wire mesh

RESULTS: 10-hr restraint produced gastric mucosal ulceration in 83% of rats; 2-hr restraint plus cold produced 96.8% ulceration. NE turnover, reflecting the level of sympathetic activity, significantly increased in the restrained rats' glandular stomach but with no significant increase in nonglandular stomach or submaxillary glands. Drug pretreatment significantly reduced the incidence of gastric ulceration; adrenalectomy and 6-hydroxydopamine did not prevent ulceration.

SOURCE: Journal of Pharmacology and Experimental Therapeutics 184(1): 163-168, 1973

AUTHOR(S): Djahanguiri, B., M.R. Zarrindast, and S. Gerayesh-Nejad

EXPERIMENT TITLE: Effects of Cold or Restraint on Incidence of Gastric Ulceration Induced in Rats By Ulcerogenic Drugs

SUBJECTS: Sprague-Dawley rats (110-150 gm)

AREA OF STUDY: Digestive; Pharmacology

OBJECTIVES: In title

PROTOCOL: Animals were fasted for 24 hr but had free access to water. Rats were restrained by placing them in a piece of galvanized steel window screen which was molded around the animal and held in place with adhesive tape. Ambient temperature = $25 \pm 2^{\circ}\text{C}$. Four groups of 50 animals/group were allocated as follows: the first 10 rats of each group received one of the 4 ulcerogenic drugs (group 1 - phenylbutazone, group 2 - aspirin, group 3 - indomethacin, group 4 - histamine) and were kept at 25°C . The second 10 rats received the drugs and were kept at 4°C . The third 10 rats received the drugs and were subjected to restraint. The fourth 10 rats received cimetidine 30 min before the drug injection and were kept at 4°C . The fifth 10 rats received the same dose of cimetidine and were restrained at ambient temperature. A fifth group (50 controls) received 1 ml/100 gm of carboxymethylcellulose (CMC) or cimetidine and were kept at $25 \pm 2^{\circ}\text{C}$. After appropriate intervals the animals were killed, the stomachs removed and inspected for gastric lesions.

IMMOBILIZATION METHOD: Steel window screen and tape

RESULTS: Animals receiving CMC or cimetidine and kept at 25°C or 4°C and those subjected to restraint and kept at 25°C did not show gastric ulceration. Exposure to cold or restraint significantly potentiated the ulcerogenic action of phenylbutazone, aspirin, and indomethacin, but not histamine. Cimetidine significantly reduced the ulcerogenic action of all four drugs.

SOURCE: European Journal of Pharmacology 51: 77-79, 1978

AUTHOR(S): Dolgun, Z.S. and S.P. Novikova

EXPERIMENT TITLE: Dynamics of Elimination of 5-Oxyindoleacetic Acid
in Rats During Prolonged Hypokinesia

SUBJECTS: Male Wistar rats (170-180 gm)

AREA OF STUDY: Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: Two series: I - 2 groups: 1) controls; 2) rats were placed for 7 wk in isolated movable cages which severely restricted their mobility. Series II - control rats from series I were placed in isolation for 28 days then placed in cages which severely restricted their mobility. During the experiment, animals were kept on a special diet: urine and feces were collected separately. Measurements: daily urinary 5-oxyindoleacetic acid (5-OIAA); body weight.

IMMOBILIZATION METHOD: Cage (isolated movable)

RESULTS: Series I: Immobilization resulted in increased 5-OIAA elimination; significant increases were noted only on days 1, 3 and 13. After 3 wk, 5-OIAA elimination decreased and after 7 wk was near normal. The greatest weight loss occurred on days 13-15, followed by weight gains. Series II - Only on the 15th day of hypokinesia was the increase in 5-OIAA significant.

SOURCE: Space Biology and Medicine 3(6): 114-115, 1969

AUTHOR(S): Dolgun, Z.S., S.P. Novikova, and V.S. Shashkov

EXPERIMENT TITLE: Effect of Prolonged Hypokinesia on Serotonin Metabolism in Rats

SUBJECTS: 420 Rats (170-180 gm)

AREA OF STUDY: Endocrine; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats were placed in restrictive cages for ~130 days. Urine and feces collected separately daily. Diet: food and water ad libitum. Measurements: 5-hydroxyindole-acetic acid (5-HIAA) in urine; serotonin (5-HT) in blood, brain stem and duodenal tissues during and after experiment.

IMMOBILIZATION METHOD: Cage

RESULTS: Motor activity restriction caused substantial 5-HT metabolism shifts. The most marked deviations from normalcy in the 5-HT content in the duodenal blood and tissues, and also in the excretion of 5-HIAA in the urine, were observed on the 1st-3rd and 13th-15th days of hypokinesia. Between the 4th and 8th wk, there was a relative stabilization of the studied indices. However, prolonged hypokinesia (more than 60 days) led to considerable impairments in 5-HT metabolism. Normalization had not set in on the 45th day after immobilization.

SOURCE: Space Biology and Medicine 5(3): 15-21, 1971

AUTHOR(S): Domonkos, J. and L. Heiner

EXPERIMENT TITLE: Effect of Denervation and Immobilization on
Carbohydrate Metabolism in Tonic and Tetanic
Muscles: I. Glycolytic Metabolism

SUBJECTS: Adult rabbits

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) denervation by unilateral section of the sciatic nerve; 2) immobilization by the mechanical fixation of one hind limb. The semimembraneous muscle was the tetanic muscle and the soleus was the tonic muscle; the intact contralateral limb served as control. Changes were studied at 14-20 day intervals. The animals were killed and the muscle immediately removed. Diet: Normal. Measurements: free and bound glycogen; pyruvate; lactic acid.

IMMOBILIZATION METHOD: Denervation; Mechanical fixation

RESULTS: Denervation did not influence glycogen content and glycolytic metabolism of tonic and tetanic muscles to the same extent. During the 1st wk postdenervation, glycogen content decreased in the tonic muscle and increased in the tetanic one; during the 2nd wk, the opposite occurred. Glycolytic metabolic activity and glycogen content changes showed a parallel behavior in both kinds of muscles. In the 2nd phase of postdenervation, glycolytic metabolism of both kinds of muscles began to show a similarity. The effect of immobilization resembled that of denervation with a few days lag.

SOURCE: Acta Physiologica Academiae Scientiarum Hungaricae 28: 227-236.
1965

AUTHOR(S): Drozdova, A.V.

EXPERIMENT TITLE: The Effect of Generalized Hypodynamia and Hypokinesia
on the Portal System of the Liver

SUBJECTS: Albino rats, rabbits

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Sixty rats and 8 rabbits were put into small cages in which they could not change body position. They were observed from 5 days to 6 months. After death, the hepatic portal system was injected with roentgenopaque medium and x-rayed. Sections from all lobes were prepared and x-rayed.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: At 1 wk (10 rats, 2 rabbits) there was faint injection of marginal parts of hepatic lobes. After 2 wk (17 rats, 1 rabbit) the marginal regions of the liver were also filled poorly. There was regular constriction of small branches of segmentary veins. After 3 wk (15 rats) the main trunks of the portal vein and main segmentary veins were wider than normal. After 4 wk (12 rats) the interlobular veins and fine branches of segmentary veins became even narrower. After 6 wk (1 rabbit) the marginal segments of the lobes were poorly injected and small branches of segmentary veins were evenly constricted. After 4 mo (2 rabbits) the main branches of the portal veins and main segmentary veins were dilated and fine segmentary and interlobular veins were evenly constricted.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 11: 100-104, 1971

AUTHOR(S): Drozdova, A.V.

EXPERIMENT TITLE: Effects of Hypokinesia (Alone) and Hypokinesia Combined With Gravitational Stress on the Structure of the Portal System of the Liver

SUBJECTS: 60 White rats (180-200 gm)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Three groups: 1) hypokinesia alone, 1-6 wk, special cramped cages precluded movement; 2) single 20 min maximum tolerable ventrodorsal stress of 9 G's, followed by 1-6 wk hypokinesia; 3) 1-6 wk hypokinesia with subsequent single stress of the same parameters as in group 2. Animals were sacrificed after the experiment using ether fumes. The portal system of the liver was injected with an India ink/gelatin compound and subsequently sliced into 90 to 120 μ sections and cleared. Measurements: morphological changes in the hepatic portal system.

IMMOBILIZATION METHOD: Cage

RESULTS: Group 1) Hypokinesia caused definite morphological changes in the portal system of the liver, indicating blood circulation disorders and venous stagnation; these phenomena increased with the duration of hypokinesia. After 1-2 wk of general hypokinesia, distension of the interlobular veins and sinusoids had begun. During the following period (3-6 wk) the manifestations of stasis spread into the venae cava; distended sinusoids in the central areas of the lobe and distension of the venae centralis. Group 2) Morphological changes indicated the prevalence of spasmodic state of the portal bed components and a reduced number of stagnation phenomena, as compared to the effects of hypokinesia alone. In the early period (1-2 wk) irregular distension of the sinusoids in the peripheral areas of the lobe; after 4 wk, venous stasis in the peripheral parts of the lobes became more pronounced; after 6 wk, the sinusoids were as widely distended in the periphery as in the central portions of the lobe. The microcirculatory bed was the first to be affected by high G forces. Group 3) Venous stagnation phenomena were more strongly pronounced as compared with the effects of hypokinesia alone. One to 2 wk after combined application of "hypokinesia - high G-force," the interlobular veins and sinusoids were acutely distended; there was a greater degree of distension and filling of the sinusoids. After 4-6 wk, these manifestations remained. Of the 2 combinations - high G-force and hypokinesia or hypokinesia and high G-force - the latter had a more unfavorable effect on the hepatic portal system.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 69(10): 50-55, 1975

AUTHOR(S): Dutton, J.W., P.J. Gwise, C.J. Chiu, W.A. Mersereau, and E.J. Hinchey

EXPERIMENT TITLE: A New Method to Study the Healing Dynamics of Acute Gastric Erosions and Its Application on Restrained Rats

SUBJECTS: Female Sprague-Dawley rats (180-200 gm)

AREA OF STUDY: Digestive; Pharmacology

OBJECTIVES: In title

PROTOCOL: Cold restraint: subjects placed in restraint cages and left in a darkened, cold room at 4°C for 3 hr. 2 experiments: 1) Healing pattern experiment: a) cold restraint only - 10 rats, sacrificed immediately after stress, stomach removed and examined; b) cold restraint, followed by immediate iv injection of 0.2 mg of colloidal carbon, particle diameter 100-200 Å - 10 groups of 10 rats each, surviving rats in each group were sacrificed at daily intervals from 1 to 10 days post-stress; controls. 2) Re-stress experiment - 20 rats, cold restraint and colloidal carbon as above; 8 days later the surviving animals were restressed with cold restraint, then sacrificed without a repeat of colloidal carbon. Measurements: incidence/site of gastric erosions, healing rate, mortality rate.

IMMOBILIZATION METHOD: Cage

RESULTS: The incidence and site of gastric erosions produced by this cold restraint technique were similar to those seen by others; erosions were confined to the glandular acid producing portion of the stomach, and rarely extended the full thickness of the gastric mucosa. The mortality of cold restrained animals varied from 0 to 30% in the groups studied. Application of the colloidal carbon technique revealed that approximately one half of acute gastric erosions in cold restraint animals were completely healed after 5 days; 90% healed by day 10. Animals stressed, labeled and then restressed 8 days later developed acute gastric erosions randomly without predilection to the sites of initial gastric mucosal damage.

SOURCE: Journal of Surgical Research 20: 499-504, 1976

AUTHOR(S): Dyskin, Ye.A., E.N. Bellendir, N.M. Patlas, and E.P. Levites

EXPERIMENT TITLE: Changes in the Microcirculatory Bed of the Compact Bone Substance Under Local Mechanical Pressure, Gravitation Stresses and Hypokinesia

SUBJECTS: Rabbits, cats

AREA OF STUDY: Skeletal; Circulatory

OBJECTIVES: In title

PROTOCOL: Three groups: 1) prolonged local mechanical pressure on the tibia for 4-33 days. The apparatus did not hinder function of the extremity; 2) subjected to chronic gravitational overload for 1 mo on alternate days by centrifugation (cats); 3) hypokinetic for 90 days in small cages (rabbits). The animals were sacrificed at the end of all 3 experimental series. The long tubular bones of the pelvic extremities were subjected to morphological study. Measurements: vessel diameter; number of vessels; volume of the vascular bed.

IMMOBILIZATION METHOD: Cage

RESULTS: Prolonged local pressure on the bone resulted in transformations characterized by lacunar resorption of the compact substance at the site of application of the force and endosteal bone formation on the opposite side of the same part of the bone. Hypergravitation caused a considerable transformation of the microcirculatory bed and of the histoarchitectonics of the compact bone substance. Smooth and linear perivascular resorption took place around dilated vessels in osteon canals. It resulted in formation of resorption cavities. In addition, processes of bone formation took place. Due to the effects of hypokinesia the transformation of compact substance was of a regressive character. The fibrous structures of the bony tissue and blood vessels lost their regular orientation and acquired a chaotic direction.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 70(1): 45-53, 1976

AUTHOR(S): Eccles, J.C.

EXPERIMENT TITLE: Disuse Atrophy of Skeletal Muscle

SUBJECTS: 26 Cats

AREA OF STUDY: Muscular

OBJECTIVES: Stimulation required to prevent atrophy; physiology of atrophy

PROTOCOL: Two groups: 1) 6 control cats; 2) 20 cats, the spinal cord was severed at the first lumbar region, along with all dorsal roots below this level on both sides. One hind limb was allowed to atrophy, while the other was given tetanic electrical stimulation of the sciatic nerve daily from 10 sec to 2 hr. After 21 days, cats were anesthetized and myographic recordings were made on the soleus, gastrocnemius, extensor digitorum longus, and the tibialis anticus. The muscles were then removed and weighed in wet and dry states.

IMMOBILIZATION METHOD: Cordotomy

RESULTS: After 21 days of disuse, the moist and dry weights of the 4 muscles investigated fell to 60% of normal. The ratio of tetanic contraction strength to muscle weight was 60%-80% of normal. Daily periods of tetanization almost prevented disuse atrophy in the tibialis anticus and extensor digitorum longus; there was much less effect in the gastrocnemius and soleus. In all stimulated muscles, the ratio of tetanic contraction to weight and the summation of twitches were not improved.

SOURCE: Medical Journal of Australia 2(7): 160-164, 1941

AUTHOR(S): Eccles, J.C.

EXPERIMENT TITLE: Investigations on Muscle Atrophies Arising from Disuse and Tenotomy

SUBJECTS: 30 Cats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Innervated muscles of the hind limb were kept inactive for several weeks as the result of section of the cord in the upper lumbar region and of all the dorsal roots below this level. For experiments involving muscle shortening or lengthening during stimulation the ankle extensors or flexors were tenotomized. Daily tetanizations of the muscle were provided by stimulation of the sciatic nerve through the skin by means of a localized pad over the nerve and a large indifferent pad. Frequency of stimulation: 40 per second; durations: 30 sec, 2 min and 4 min.

IMMOBILIZATION METHOD: Cordotomy; Tenotomy

RESULTS: The ankle flexors and extensors atrophied to about 60% of normal in 3 wk; both the tetanic contraction tension per unit weight and the tetanus to twitch ratio fell to low values. Stimulation to prevent atrophy was least effective in shorter muscles. Muscles pulling against an isotonic load and allowed to shorten and lengthen during the daily stimulations atrophied less than those stimulated in the fixed condition of maximum physiological shortening. Tenotomy gave rise to loss of weight and of contraction response somewhat resembling those of disused muscles.

SOURCE: Journal of Physiology 103: 253-266, 1944

AUTHOR(S): Edgerton, V.R., R.J. Barnard, J.B. Peter, A. Maier, and D.R. Simpson

EXPERIMENT TITLE: Properties of Immobilized Hind-Limb Muscles of the *Galago senegalensis*

SUBJECTS: 7 Lemurs (*Galago senegalensis*) (240 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: The right hind limbs of the animals were externally immobilized for 6 mo with an aluminum brace which extended from the upper thigh to the toes with the knee and ankle fixed at right angles. Measurements: electromyographic (EMG) activity; muscle weight and fiber size; biochemistry of homogenates; contractility.

IMMOBILIZATION METHOD: Aluminum brace

RESULTS: EMG was markedly reduced in the restrained muscle compared with the contralateral control. Extensor muscles atrophied more than flexors. The soleus muscle atrophied more than any other muscle of the lower leg, but the vastus intermedius of the thigh did not. Slow-twitch oxidative fibers (S0) were atrophied more than fast-twitch oxidative glycolytic fibers (FOG) and FOG tended to atrophy more than fast-twitch glycolytic fibers (FG). Restrained soleus and vastus intermedius had a smaller percentage of S0 fibers than their controls. There was no consistent pattern in alterations in reduced nicotinamide adenine dinucleotide diaphorase activity, except for a greater coarseness of staining granules and more homogenous dispersion of the granules throughout the cross-section of fibers. No changes were found in phosphorylase, lactate dehydrogenase, or succinate dehydrogenase specific activity or in myoglobin concentration in homogenates of ankle flexors or the vastus lateralis. Myosin ATPase, but not actomyosin ATPase activity was significantly less in the restrained gastrocnemius-plantaris muscles. No change in contractile properties related to speed were seen in the plantaris; but the plantaris did exert more twitch and tetanic tension per gm of muscle in the restrained leg.

SOURCE: Experimental Neurology 46: 115-131, 1975

AUTHOR(S): Edlich, R.F., L. Urdaneta, and C. Hansen

EXPERIMENT TITLE: Gastric Blood Flow and Its Distribution During Restraint

SUBJECTS: 17 Mongrel dogs

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 9 dogs were placed in a restraint cage in a secluded room for 3 days; 2) 8 controls. Dogs received no food or water for 18 hr prior to blood flow determination. 72 hr after initiation of the experiment, gastric blood and its distribution was determined in the 2 groups of dogs by radio-rubidium clearance techniques. Prior to the blood flow determination, a precise volume of rubidium chloride Rb^{86} was introduced into the venous catheter. Green dye was infused via venous catheter during the blood flow determination. Five sec after the dye injection, the dogs were sacrificed and their stomachs were removed and trimmed of large vessels. Measurements: gastric blood flow; cardiac output; perfusion rates of the corpus and antrum; uptake of green dye by the gastric mucosa.

IMMOBILIZATION METHOD: Cage

RESULTS: The mean gastric perfusion rate of the restrained dogs was 35% lower than that of controls. There was a comparable decrease in blood flow to the corpus and antrum. The distribution of gastric blood flow among the tissue layers of the stomach of the restrained dogs did not differ significantly from the controls. The cardiac output during restraint was 25% less than controls.

SOURCE: Aerospace Medicine 40: 600-602, 1969

AUTHOR(S): Eichelberger, L., M. Roma, and P.V. Moulder

EXPERIMENT TITLE: Effect of Immobilization Atrophy on the Histochemical Characterization of Skeletal Muscle

SUBJECTS: Puppies

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 12-14 wk old, 4-5 wk immobilization; 2) 13-17 wk old, 6-7 wk immobilization; and 3) 17-20 wk old, 8-11 wk immobilization. Puppies were maintained in metabolism cages until immobilization. One hind limb was immobilized as follows: the proximal third of the femur was wired with stainless steel wire to the mid-tibial area and the distal third of the femur to the wing of the ilium; the wires were passed around the long bones and through the punctured ilium and after approximation of the limbs in tight flexion, the wire was fixed and buried. Puppies were killed at different ages to obtain calf and thigh muscle groups. Measurements: serum: water, chloride, sodium, potassium, calcium, magnesium, and total nitrogen; muscle: fat, water, chloride, sodium, potassium, calcium, magnesium, total nitrogen, and collagen nitrogen.

IMMOBILIZATION METHOD: Internal fixation with stainless steel wire

RESULTS: There was a progressive increase in total neutral fat content depending upon the length of immobilization. Irrespective of age or restraint duration, extracellular compartment mass increased; intracellular water content and solid mass decreased. Histochemically, the internal structure of the muscle fibers did not change under restraint. In all groups, the percentage of muscle fiber water and potassium and magnesium concentration were the same in all calf and thigh muscle groups from both control and restrained legs.

SOURCE: Journal of Applied Physiology 12: 42-50, 1958

AUTHOR(S): Eichler, J.H.

EXPERIMENT TITLE: Bone Atrophy by Inactivity

SUBJECTS: 300 Male guinea pigs, inbred strain (5 weight groups, 100-1000 gm)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Immobilization: pelvic plaster, hip and knee joints were fixed at an angle of 90°; average time of fixation was 3 wk; within 1 group of medium weight, immobilization of adolescent animals was carried out for 1, 2, 3, 4, 5 and 6 wk. Animals could crawl within the cage. Diet: adequate. Measurements: breaking strength of femorae; reduction of spongy bone by uncalcified bone sections; bone remodelling; dry mass of bone; mineral balance.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: There was a linear decrease of the physiological breaking strength in the femorae, noted up to 6 wk, depending upon age and sex. The youngest guinea pigs had the highest loss of strength within the weight class around 150 gm; they lost 55% of the physiological breaking strength after 2 wk immobilization. The femorae of adult animals lost 43.7% after 3 wk. The spongy bone of the femur revealed a loss of 36% trabecula after 2 wk immobilization; after 4 wk only 1/3 of the original spongy bone was present. Quantitative calculations of bone remodeling amount of active osteons decreased to 50% after 3 wk immobilization; amount of resorption channels increased tenfold; inactive osteons were doubled; two-to four-fold increase of osteoclasts in comparison to controls; reduction of osteoclasts. The average dry mass of bone decreased in comparison to controls; the loss of mineral substance was between 10.8% and 19.% of the remaining bone. The calcium and phosphorus balances became significantly negative during 3 wk of immobilization; immobilization had no significant influence upon the elimination of potassium.

SOURCE: Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio, December 1971, 22 pp. (AMRL-TR-71-29; Paper No. 11)

AUTHOR(S): Elias, P.K. and E. Redgate

EXPERIMENT TITLE: Effects of Immobilization Stress on Open Field Behavior and Plasma Corticosterone Levels of Aging C57BL/6J Mice

SUBJECTS: 76 Male C57BL/6J mice

AREA OF STUDY: Behavior; Endocrine

OBJECTIVES: In title

PROTOCOL: Age groups: 2.2, 6.2, 12 and 23.3 mo. On the 1st day of the experiment the animals were individually tested in the open field for 2 5-min periods. Locomotor activity and exploration were observed. 10 days after the initial open-field testing, mice were equally divided into experimental and control groups. The experimental groups were subjected to a 10-min immobilization period on the 11th day. A standard plastic animal holder mounted on a warming plate was used. The control subjects were brought from the colony and placed on the warming plate for approximately 10 sec, and returned to their cages to control for any stresses encountered from cage transport and handling. All mice were returned to their cages for 24 hr before the second open field test. Diet: Purina Lab Chow and water ad libitum. Measurements: blood pressure; circulating plasma corticosterone levels; behavior.

IMMOBILIZATION METHOD: Animal holder

RESULTS: Eleven days postimmobilization, elevated corticosterone levels were seen for all but the 12 mo age group. No behavioral effects were seen in experimental mice, although locomotor activity and exploratory behavior declined with advancing age.

SOURCE: Experimental Aging Research 1(1): 127-135, 1975

AUTHOR(S): Eranos'yan, T.K.

EXPERIMENT TITLE: Mechanism of Action of Sodium Chloride-Sulfate Mineral Waters During Experimental Hypodynamia

SUBJECTS: 30 Female white rats (254.5-264 gm)

AREA OF STUDY: Fluid and Electrolyte; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 10 controls, allowed free access to normal water supplies; 2) 10 rats, kept in small individual cages and had access to normal water supplies; 3) 10 rats, kept in small individual cages but received mineral water twice a day from an automatic feeder. The experiment lasted 26 days, at the end of which the blood was taken and the liver excised. Measurements: soluble minerals and proteins in a centrifuged liver homogenate; various levels of proteins and minerals in blood serum; total oxygen use; number of erythrocytes and leucocytes; blood hemoglobin.

IMMOBILIZATION METHOD: Cage

RESULTS: Hypokinesia by itself caused alterations in a number of biochemical indices; a reduction in overall protein and the activity of a number of enzymes. Drinking of the mineral water prevented abnormal indices of malate dehydrogenase, lactate dehydrogenase, sorbitol dehydrogenase, cholinesterase, and guanase, and elevated alanine and asparagine transaminases. It increased the activity of other enzymes, and also increased erythropoiesis.

SOURCE: Voprosy Fizioterapii, Kurortologii i Reabilitatsii, Vil'nyus, pp. 336-340, 1978

AUTHOR(S): Eronen, I., T. Videman, C. Friman, and J.E. Michelsson

EXPERIMENT TITLE: Glycosaminoglycan Metabolism in Experimental Osteoarthrosis Caused by Immobilization

SUBJECTS: 16 Rabbits

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: The right knee of each animal was immobilized in extension by means of a plastic splint and by bandaging the knee region. The left knee served as a control. Six rabbits were used for pilot experiments; the remaining 10 were killed after 2, 6, 10, 17 and 30 days of immobilization. 24 hr before they were killed, the animals were given 0.26 mCi/kg ^{35}S -sulfate im. Cartilage samples were taken from the tibial weight-bearing region, tibial margin, femoral condyle and femoral head. The concentration of glycosaminoglycans (GAG) in the tissues was measured by determination of hexosamine and uronic acid. The uptake of ^{35}S -sulphate was used as an indicator of the synthesis rate of sulphated glycosaminoglycans.

IMMOBILIZATION METHOD: Plastic splint and bandage

RESULTS: Immobilization caused an increased specific ^{35}S activity of varying degree in cartilage from all sites studied, i.e., an increased synthesis rate of sulphated GAG. This increase was most pronounced by far in tibial marginal cartilage, where there was a rise in GAG concentration as well, indicating that net synthesis occurred. In tibial weight-bearing and in femoral condylar cartilages immobilization caused GAG depletion indicating that the GAG degradation rate was increased more than the synthesis rate. In femoral head cartilage, the GAG concentration was not affected by immobilization.

SOURCE: Acta Orthopaedica Scandinavica 49: 329-334, 1978

AUTHOR(S): Esaki, K.

EXPERIMENT TITLE: Morphological Study of Muscle Spindle in Atrophic Muscle Induced by Immobilization with Plaster Cast

SUBJECTS: White male rabbits (25 kg)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: The right hind limb was immobilized in plaster casts in different positions. 2 groups: 1) knee and ankle were flexed to the maximal degree; 2) knee was flexed and the ankle was extended to the maximal degree. Periods of immobilization varied from 1-9 wk. Rabbits which developed bedsores and infection were excluded from the experiment. Animals were sacrificed by injection of air in veins. Measurements: state of joint contracture; muscle weight and morphological examination of muscle spindles (m. plantaris, m. soleus, m. tibialis); body weight; mortality; general behavior.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: The body weight of experimental animals decreased slightly. The mortality of the 2nd group was much higher (32% vs. 5.6%). The atrophic state of the immobilized muscles became significant in parallel with periods of immobilization but the degree of hindrance of joint mobility was not dependent on the position of immobilization. Muscles fixed at extended position reduced their weight to a lesser degree or even increased it, compared with the weight loss of the muscles fixed at a relaxed position. The degeneration of immobilized muscle spindle was recognized after 1 wk of restraint.

SOURCE: Nagoya Medical Journal 12(3): 185-210, 1966

AUTHOR(S): Evans, E.B., G.W.N. Eggers, J.K. Butler, and J. Blumel

EXPERIMENT TITLE: Experimental Immobilization and Remobilization of Rat Knee Joints

SUBJECTS: Adult male Sprague-Dawley rats

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: The left knee was immobilized in partial flexion by an internal plexiglas splint secured on the lateral aspects of the femur and tibia with steel pins through corresponding drill holes in the splint and bones. The splint was passed through the muscles of the thigh and leg. The right knee served as a control as well as rats in which only pins were placed in the tibia and femur. Immobilization was maintained for periods of 15, 30, 45, 60 or 90 days. Remobilization after 45 or 110 day immobilization was by: 1) abrupt forced movement; 2) gradual passive movement; or 3) pure active movement. Measurements: histological study of muscle; bone; cartilage; connective tissue and synovial membrane.

IMMOBILIZATION METHOD: Internal fixation by plexiglas splint and steel pin

RESULTS: Immobilization with a slight range of motion did not prevent structural changes. After prolonged immobilization, the contracture of both the muscles and the capsule was responsible for the restriction of movement. The primary responses to limited motion were the proliferation of intracapsular connective tissue and the formation of adhesions; these changes were reversible to a limited degree. Major cartilage alterations, such as matrix fibrillation, cleft formation and ulceration and their adjacent subchondral lesions, resulted from abnormal friction and pressure in a joint limited of motion; these changes were irreversible. Joint changes are reversible if immobilization does not exceed 30 days. After 60 days, all major joint alterations had appeared and with even longer immobilization only the degree of joint alterations changes. The 3 methods of remobilization were equally effective in restoring the range of motion.

SOURCE: Journal of Bone and Joint Surgery 42-A(5): 737-758, 1960

AUTHOR(S): Fedorov, I.V. and L.A. Grishanina

EXPERIMENT TITLE: Nitrogen Metabolism in Animals Exposed to Hypokinesia

SUBJECTS: Rats

AREA OF STUDY: Metabolism and Energy Exchange; Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: Three series: 1) 4 rats for 22 days; 2) 7 rats for 24 days; 3) 7 rats for 15 days. Each rat was placed in an individual small open-air compartment of a special metabolism cage fabricated from plastic materials. The tail of each rat was held to a metal pin in the cage by adhesive plaster. A plaster jacket was fitted onto each animal for immobilizing it. These jackets were cast from plastic models of the rats and corresponded to the size of the experimental animals. Urine and feces were collected daily. Diet: ad libitum. Measurements: total nitrogen, urea, uric acid, creatinine and phosphorus in the urine before and during immobilization; body weight; behavior.

IMMOBILIZATION METHOD: Plaster jacket

RESULTS: During hypokinesia, the animals were listless and inactive. Their desire for food was reduced. Body weight decreased by 15-30% from the initial level. All the indices of nitrogen metabolism changed sharply from the first days of immobilization; there was an increase of diuresis. The content of total nitrogen in the urine increased by 50-100%. The release of urea increased proportional to the quantity of total nitrogen. The content of creatinine and uric acid increased slightly from the first days attaining a maximum of 30-50% of the initial level on the 9th-12th day of immobilization. The creatinine content in the urine increased by more than four-fold. The release of phosphorus in the urine increased.

SOURCE: Space Biology and Medicine 1(3): 66-72, 1967

AUTHOR(S): Fedorov, I.V., V.N. Vinogradov, Yu.I. Milov, and L.A. Grishanina

EXPERIMENT TITLE: Synthesis of Tissue Proteins in Animals During Hypodynamia

SUBJECTS: White male rats (160-200 gm)

AREA OF STUDY: Metabolism and Energy Exchange; Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental rats were placed in separate compartments of special metabolism cells made of organic glass for 2, 10 and 15 days. Radioactive amino acids were injected ip 1, 2 and 4 hr before the animals were sacrificed in amounts calculated as equalling 10,000 counts per min/gm body wt. After decapitation, the liver, kidneys, heart, spleen, part of the small intestine and the skeletal muscles were taken from the rats for investigation. The radioactivity was determined. Diet: water and concentrated food ad libitum.

IMMOBILIZATION METHOD: Cell

RESULTS: The rate of labeled amino acid incorporation into the protein of the liver, kidney, spleen, small intestinal wall, heart and skeletal muscle tissues was decreased in all cases under hypodynamia. When the time of hypodynamia was lengthened, the degree of decreased incorporation of label into the tissue proteins was, as a rule, also increased. Six days after 15 days of hypodynamia, there was only an inclination toward a normalization of the rate of label incorporation into the proteins of all the tissues studied. Normalization of the peripheral blood picture had likewise not commenced, nor had the glycogen level in the liver or weight of the adrenals begun to normalize.

SOURCE: Space Biology and Medicine 1(1): 64-68, 1967

AUTHOR(S): Fedorov, I.V., Yu.I. Milov, V.N. Vinogradov, and
L.A. Gryshanina

EXPERIMENT TITLE: Body Weight and Protein Synthesis in Animals During
Hypokinesia

SUBJECTS: 217 Male white rats (140-200 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats were placed in individual small open-air compartments of special metabolism cages fabricated from plastic materials. The tail of each rat was held to a metal pin in the cage by adhesive plaster. A plaster jacket was fitted onto each animal for immobilizing it. These jackets were cast from plastic models of the rats and corresponded to the size of the experimental animals. Diet: rich, concentrated feed ad libitum; water ad libitum. Measurements: body weight; absolute and relative weights of liver, kidneys, heart, testes, and skeletal muscles; liver glycogen content; skeletal muscle total nitrogen and intensity of tissue proteolysis.

IMMOBILIZATION METHOD: Plaster jacket

RESULTS: There was an initial weight loss until rats adapted to the stress. Growth was retarded under hypokinesia. The absolute weight of the liver, right kidney, heart, testes, and skeletal muscles of the rear extremities decreased; relative weight for these organs, with the exception of the skeletal muscles (6% decrease) increased 4, 18, 16 and 13%, respectively. There was no difference between experimentals and controls in the quantity of total nitrogen per gm of raw skeletal muscle tissue. Proteolytic intensity did not change in 3 days of hypokinesia, but increased slightly after 15 days. Total liver glycogen was sharply decreased (average, 89%).

SOURCE: Space Biology and Medicine 2(1): 27-31, 1968

AUTHOR(S): Fedorov, I.V., Yu.I. Milov, and Ye.Ye. Simonov

EXPERIMENT TITLE: Dynamics of Changes in Protein Metabolism in Rats
During Prolonged Hypokinesia

SUBJECTS: 75 Rats

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental rats were placed in individual small open-air compartments of special metabolism cages fabricated from plastic materials. The tail of each rat was held to a metal pin in the cage by adhesive plaster. A plaster jacket was fitted onto each animal for immobilizing it. These jackets were cast from plastic models of the rats and corresponded to the size of the experimental animals. 25 experimental animals were killed on the 15th day of immobilization and 10 were killed on the 60th day. The intensity of tissue protein synthesis was determined. In addition, changes in body weight of the animals, weight of individual organs, total nitrogen content in the tissue of skeletal muscles and activity of blood serum transaminase were determined.

IMMOBILIZATION METHOD: Plaster jacket

RESULTS: Rat growth slowed down during hypokinesia. After 15 days, body weight was 34% lower than controls and after 60 days, 48% lower. Similarly, organ weights were reduced. Weight of the skeletal muscles decreased by 6% after 15 days, but after 60 days it was the same as in the controls. Nitrogen content of the skeletal muscles remained unchanged after 15 days immobilization but after 60 days, increased by 7%. Labeled tryptophan-1-C-14 studies showed a reduced organ uptake after 15 days immobilization and remained at this low level after 60 days. Proteolysis increased as indicated by the increased serum transaminase activity. Tissue protein synthesis was depressed. After 60 days, depressed protein metabolism did not show any indications of returning to normal.

SOURCE: Space Biology and Medicine 4(3): 27-31, 1970

AUTHOR(S): Fedorov, I.V.

EXPERIMENT TITLE: Intensity of Tissue Autolysis in Animals During Hypokinesia

SUBJECTS: Male rats (160-180 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Three groups: 1) control; 2) 15-22 days of hypokinesia; 3) 51-59 days of hypokinesia. Each experimental rat was placed in an individual small open-air compartment of a special metabolism cage fabricated from plastic materials. The tail of each rat was held to a metal pin in the cage by adhesive plaster. A plaster jacket was fitted onto each animal for immobilizing it. These jackets were cast from plastic models of the rats and corresponded to the size of the test animals. Autolysis intensity was determined in tissues of the liver, kidney, heart, skeletal muscles, and brain of the control animals and in animals killed on the 15th-22nd and 51st-59th days of hypokinesia. Autolysis intensity was judged from the increase in free amino acids in the tissue homogenate.

IMMOBILIZATION METHOD: Plaster jacket

RESULTS: After 15-22 days hypokinesia, the total content of free amino acids in rat tissues was similar to normal control animals. On the 51st-59th days of hypokinesia the content of free amino acids in all investigated tissues exhibited a reliable decrease. The intensity of autolysis in all tissues other than the muscle tissue exhibited a reliable decrease after 2 or 3 wk. During the 8th-9th wk of immobility, the autolysis intensity had increased reliably in all tissues other than in the cardiac muscle.

SOURCE: Space Biology and Medicine 5(5): 128-130, 1971

AUTHOR(S): Fedorov, B.M. and V.S. Nevstruyeva

EXPERIMENT TITLE: Changes in the Sympathicoadrenal System Caused by Exposure in a Permanent Magnetic Field

SUBJECTS: 30 Rabbits

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 10 rabbits were confined for 24 hr in hypokinetic cages; 2) 10 were placed in similar cages and simultaneously exposed to a permanent magnetic field (1000 oersted) for 24 hr, and 3) controls. All were decapitated. Measurements: adrenaline and noradrenaline content of hypothalamus, heart, and suprarenals.

IMMOBILIZATION METHOD: Cage

RESULTS: Group 1: 24-hr hypokinesia considerably reduced noradrenaline in the hypothalamus and myocardium but did not affect adrenaline in the medullary layers of the suprarenals. Group 2: 24-hr hypokinesia and magnetic field exposure prevented any decrease in noradrenaline in the hypothalamus and myocardium.

SOURCE: Space Biology and Medicine 5(2): 53-59, 1971

AUTHOR(S): Federov, I.I., Z.P. Federova, Y.N. Pekus, and T.L. Sakun

EXPERIMENT TITLE: Changes in Leukocyte Stability in Hypodynamia

SUBJECTS: 50 Male albino rats (200-250 gm)

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) hypokinesia - 30 days; 2) controls. Blood was taken from the major vessels. Measurements: leukocytolysis; content of lactic and pyruvic acids. Note: experimental investigation was also performed on healthy, adult humans under conditions of hypodynamia, and the results were reported in the text.

IMMOBILIZATION METHOD: Cage

RESULTS: Restricted motor activity was accompanied by an increase of leukocytolysis (two-three fold). The content of lactic and pyruvic acids increased during restricted movement in the blood of the experimental animals.

SOURCE: Vrachebnoe Delo No. 4: 44-48, 1972

AUTHOR(S): Fedorov, I.V.

EXPERIMENT TITLE: Free Amino Acid in Animal Tissues During Hypodynamia

SUBJECTS: Male rats (100-180 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats were immobilized by placing them in gypsum fitted jackets. Measurements: the content of 11 free amino acids in the tissues of the liver, kidneys, heart, skeletal muscle and brain for the controls and animals killed on the 15th-20th and 45th-60th days of hypodynamia was determined by the method of one-dimensional descending paper chromatography.

IMMOBILIZATION METHOD: Gypsum fitted jacket

RESULTS: Immobilization caused a lag in growth and a decrease in body weight. During the first 2 or 3 weeks of hypodynamia, the total sum of the content of all free amino acids in the investigated tissues, excluding the heart, on the average was 10% higher than in the control rats. During prolonged hypodynamia (45-60 days), the total sum of amino acids in all the tissues was reduced on the average by 20% of their level in the control rats. In the cardiac and cerebral tissues, there was a considerable decrease in the quantity of alanine.

SOURCE: Space Biology and Medicine 7(5): 51-56, 1973

AUTHOR(S): Fedorov, B.M., V.P. Krotov, and Ye.N. Zhuravleva

EXPERIMENT TITLE: Changes of Some Blood Indices and Myocardial Electrolyte Content During Hypokinesia

SUBJECTS: 112 Male chinchilla rabbits (3.3-4.0 kg)

AREA OF STUDY: Blood; Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: Two groups: 1) hypokinesia - up to 62 days, 64 rabbits; 2) controls - 48 rabbits. Simultaneous intravenous administration of a certain quantity of indicator mixture T-1824, sucrose and antipyrine, allowed for determination of the volumes of plasma, extracellular fluid, and the total water in the body during the experiment several times in the same animals. Subjects were killed with an electric current at the termination of hypokinesia. Measurements: concentration of electrolytes (K, Na, Ca and Mg) and water in serum, hematocrit index, and hemoglobin quantity (determined in the initial state and further every 7 days); water, K, Na, and Cl contents in cardiac muscle; protein content in serum; volume changes of circulating blood, volume ratios between extra- and intra-cellular liquids; body weight.

IMMOBILIZATION METHOD: Cage

RESULTS: The weight of the hypokinetic rabbits was reduced as follows: 15th day - 11%, 30th day - 21%, 60th day - 27%. The quantity of body water per unit of weight did not significantly differ from that established for same animals before the start of the experiment and in the control animals. Extra-cellular fluid reliably decreased; intra-cellular fluid increased. Blood plasma volume decreased during the first month and was restored during the second. Protein content: reduced after 3-4 wk, increased level by 7th wk, and by 62nd day corresponded to initial level. Albumin content decreased during the 1st month and was restored during the 2nd; globulin concentration increased during the 1st 30 days and was reduced during the second month. Hematocrit number was gradually reduced, as was hemoglobin. The volume of circulating blood relative to a unit of weight was reduced on the 30th and 45th days, but within 2 months was normalized. No reliable changes in serum K and Mg levels; the Ca concentration was reduced for a short time in the 4th wk; Na concentration decreased and reduction was maintained until the end of the experiment. Concentration of K ions remained unchanged in myocardium, while Na ions increased.

SOURCE: Patologicheskaiia Fiziologiia i Eksperimentalnaia Terapiia
17(6): 27-31, 1973

AUTHOR(S): Federov, I.V., Yu.P. Ryl'nikov, and T.M. Lobova

EXPERIMENT TITLE: Content of Lipids in Blood and Tissues of Animals
During Hypodynamia

SUBJECTS: 97 Rats (180-220 gm) and 50 rabbits (2.5-3 kg)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Four groups: 1) nonrestrained control rats; 2) rats restrained in plaster housings for 3, 5, 10, 15, 30 and 60 days; 3) nonrestrained control rabbits; 4) rabbits restrained in wooden cages for 3, 5, 10, 15, 30 and 60 days. Rats and rabbits were killed, and blood, liver, heart, and aorta were removed. Diet: oats, black bread, beets, carrots and hay (rabbits only), water ad libitum. Measurements: cholesterol, total lipids, phospholipids and β -lipoprotein.

IMMOBILIZATION METHOD: Plaster housing (rats); Wooden cage with movable walls (rabbits)

RESULTS: The cholesterol level in blood serum increased continuously in both rats and rabbits. β -lipoproteins increased by the end of the experiment to 104% for rats, and 145% in rabbits. The coefficient of phospholipids/cholesterol was lower after the 10th day of hypodynamia. Liver lipids decreased, while liver cholesterol increased in both rats and rabbits. In the heart tissue of both rats and rabbits, lipids were reduced moderately and cholesterol increased. Study of the aorta, done only in the rabbits, showed that the quantity of lipids was reduced till the 10th day, whereupon it increased above control level after 30 days. Cholesterol content of the aorta was reduced on the 10th day, increased by the 30th day, but decreased by the 60th day.

SOURCE: Kardiologiya 13(7): 50-54, 1973

AUTHOR(S): Fedorov, I.V. and I.F. Shurova

EXPERIMENT TITLE: Content of Protein and Nucleic Acids in the Tissues of Animals During Hypokinesia

SUBJECTS: 88 Rats

AREA OF STUDY: Metabolism and Energy Exchange; Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) experimental rats, kept immobilized in special cages; 2) controls, kept under vivarium conditions. The rats were bled after 15, 30 and 60 days of hypokinesia. The gastrocnemius muscles, liver, kidneys, heart and brain were isolated and studied. Measurements: protein, DNA and RNA content of the liver, kidneys, heart, brain, and skeletal muscles; body weight; weight of gastrocnemius muscles.

IMMOBILIZATION METHOD: Cage

RESULTS: The weight of the gastrocnemius muscles decreased by almost a factor of two, the protein content decreased substantially and the DNA and RNA quantity increased. The content of protein also decreased in the tissues of the liver, kidneys and heart; the DNA quantity did not change, whereas the RNA quantity either did not change or in certain periods increased. Body weight decreased.

SOURCE: Space Biology and Medicine 7(2): 22-28, 1973

AUTHOR(S): Fedorov, I.V., A.V. Chernyy, and A.I. Fedorov

EXPERIMENT TITLE: The Rate of Synthesis and Decomposition of Tissue Proteins in Hypokinesia and Increased Muscular Activity

SUBJECTS: 108 Rats

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Three groups: 1) hypokinesia - produced by placing animals in small, individual plexiglas cages; 2) increased muscular activity - achieved by systematic physical loading (swimming); 3) control. Duration: 60 days. Animals were administered ip a mixture of three amino acids of equal radioactivity (alanine-2- ^{14}C , phenylalanine-1- ^{14}C , aspartic acid-1- ^{14}C) at the rate of 10000 counts per gm of body weight. Measurements: the radioactivity of skeletal muscle, liver, kidney, heart, and blood proteins, determined 1, 3, 6, 12, 24 and 48 hr after administration; body weight.

IMMOBILIZATION METHOD: Cage (small plexiglas)

RESULTS: The weights of the animals decreased (-40%) in 60 day hypokinesia and increased (+12%) during increased muscular activity. Hypokinesia: tissue protein synthesis rate was depressed (average tissue radioactivities were lower); protein decomposition occurred more actively. Increased muscular activity: tissue protein synthesis rate increased (average tissue radioactivities were higher); protein decomposition increased (the drop in activity between the highest peak of radioactivity curve and its 24 hr level was considerably higher than for control animals). Most distinct changes in both groups occurred in the skeletal muscle and heart proteins.

SOURCE: Fiziologicheskii Zhurnal SSSR Imeni I M Sechenova 63(8): 1128-1133, 1977

AUTHOR(S): Fedorov, I.V.

EXPERIMENT TITLE: Motor Activity and Prevention of Consequences of Hypokinesia (On the Basis of Indices of Tissular Metabolism)

SUBJECTS: 240 Mongrel albino rats

AREA OF STUDY: Behavior; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Six groups: 1) hypokinesia in cages alternated every other day with unrestricted movement, 90 days; 2) hypokinesia combined with exercise, swimming every 3rd day; 3) hypokinesia; 4) exercise; 5) hypokinesia for 90 days and recovery period for 1 mo; 6) controls. Tissues of the liver, kidneys, brain and skeletal muscle of rats decapitated on the 15th, 30th, 60th, and 90th experimental days were examined. Measurements: body weight; protein and nucleic acid content of liver, kidneys, brain, gastrocnemius muscle.

IMMOBILIZATION METHOD: Cage (with sliding walls)

RESULTS: Hypokinesia: weight declined. Reliable decrease in protein content, increase in DNA content of skeletal muscles; on days 15 and 30 there was an increase in RNA. In the late stages of hypokinesia, there was a decrease in protein of renal tissue and the brain, while it increased in the liver. DNA increased in the liver and kidneys, with a tendency toward increase in brain. Appreciable RNA increase in liver, no change in kidneys and brain. Hypokinesia alternated with freedom of movement: no changes in protein of skeletal muscles, DNA above normal, RNA increased more than in above; protein dropped in liver, rose in kidneys, no change in brain. DNA changed little in liver and brain, rose in the kidneys. No appreciable RNA change in liver/brain, significant increase was noted in the kidneys on the 60th day. Hypokinesia and exercise: changes in tissues elicited were usually in the opposite direction from those with hypokinesia; however, for the first 2 wk, swimming and limited mobility had similar effects as nonspecific stimuli. Protein - reliable decrease in brain by day 60, normalization of content in muscles, liver and kidneys by day 90; RNA/DNA levels - in skeletal muscles, above control on day 15 close to latter on 30, dropped by 60 and rose by 90; DNA remained high in liver and kidneys, declined in brain only on the 60th day. RNA decreased in liver on 30th day, higher than control at later times; in the kidneys and brain was same as with hypokinesia alone. Exercises had a normalizing effect on hypokinesia only after some periods.

SOURCE: Space Biology and Aerospace Medicine 12(2): 73-79, 1978

AUTHOR(S): Ferguson, A.B., Jr., L. Vaughan, and L. Ward

EXPERIMENT TITLE: A Study of Disuse Atrophy of Skeletal Muscle in the Rabbit

SUBJECTS: Male white rabbits (2-5 kg)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: The rabbits were anesthetized with nembutal and full-limb plaster casts were applied. Four basic positions of immobilization were used: 1) knee flexed at right angle; 2) ankle extended in some and flexed in others; 3) knee extended; and 4) same as 2. The animals were kept in their casts from 1-10 wk after which they were killed with nembutal and the tibialis anterior and gastrocnemius were removed and weighed. Diet: standard with greens and carrots added twice weekly. Measurements: weight; chemistry; histology; blood flow rate.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: There was: 1) a fundamental difference in the reaction to restraint of the tibialis anterior and the gastrocnemius; 2) increased blood flow in both atrophy and hypertrophy of skeletal muscle; 3) a change in intracellular constituents without water content change due to atrophy and hypertrophy; 4) a suggestion that tension protected against atrophy in the tibialis anterior; and 5) a metabolic change in the skeletal muscle due to atrophy and hypertrophy.

SOURCE: Journal of Bone and Joint Surgery 39-A(3): 583-596, 1957

AUTHOR(S): Filaretov, A.A. and L.V. Vasilevskaya

EXPERIMENT TITLE: Hypothalamic Electrical Activity During Stress

SUBJECTS: Male rabbits (2.5-3 kg)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Nichrome semimicroelectrodes were implanted into the hypothalamus 10-14 days before the beginning of the experiment. The discharge frequency of a neuron pool was recorded for 30 min before and 60 min after the beginning of immobilization. The firing rate was determined over a period of 15 sec at least once every 2 min. Measurements: electrical activity of the anterior, medial, and lateral hypothalamus; blood corticosteroid concentration.

IMMOBILIZATION METHOD: Not stated

RESULTS: Immobilization led to activation of the pituitary-adrenocortical system, as shown by an increase in the blood corticosteroid concentration. Activation of the medial and inhibition of the anterior and lateral hypothalamus were observed during stress. No significant changes in discharge frequency were observed in the control experiments.

SOURCE: Bulletin of Experimental Biology and Medicine 84(7): 919-921, 1977

AUTHOR(S): Filippov, S.P.

EXPERIMENT TITLE: Gamma-Aminobutyric Acid in the Brain of Hypokinetic Rats

SUBJECTS: 60 Male rats (180-200 gm)

AREA OF STUDY: Nervous; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Immobilization: 3, 7, 15, 30 and 60 days (10 rats/period). The animals were placed in small individual plexiglas cages. The rats were decapitated and the brain was rapidly removed. Measurements: amino acids in the cerebral hemispheres with basal ganglia.

IMMOBILIZATION METHOD: Cage (small, plexiglas)

RESULTS: Elevation of GABA level and particularly glutamic and aspartic acid levels was observed after 3 days of immobilization; it lasted to the 7th day of hypokinesia. However, the changes were statistically unreliable ($p > 0.05$). The increase in dicarboxylic amino acids was more marked: by 20 and 40% for glutamic and aspartic acids, respectively. From the 15th to 30th day of hypokinesia the level of free dicarboxylic amino acids of the brain dropped and gradually reverted to normal. GABA content did not differ from the control. Severe changes in amino acid content were observed by the 60th day of hypokinesia: drop of levels of GABA and aspartic acid (by 26 and 78% respectively). This was associated with a close to 50% increase in concentration of glutamic acid.

SOURCE: Space Biology and Medicine 12(1): 110-112, 1978.

AUTHOR(S): Fischbach, G.D. and N. Robbins

EXPERIMENT TITLE: Changes in Contractile Properties of Disused Soleus Muscles

SUBJECTS: Male Osborne-Mendel rats (150-200 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups; 1) controls; 2) ankle and knee joints were immobilized in mid-position by driving 22- or 25-gauge needles through the calcaneus into the distal tibia and through the distal femur into the proximal tibia respectively. Animals had steel electrodes placed in the soleus, extensor hallucis longus and gracilis anterior muscles of one leg, with a plug fixed on the back of each rat. Electromyographic (EMG) recordings were taken for 30 min each day at period of maximum activity. At 2 and 4 wk after limb immobilization, rats were killed, muscles were removed and mechanical properties were studied "in vitro" at 23-26°C with isometric techniques. A series of prolonged tetanic shocks, each tetanus at a progressively higher frequency, was applied until the maximum tetanic tension was attained. Measurements: contraction time; maximum tetanus-twitch ratio; 5 second tetanus-twitch ratio; the maximum rate of tetanic tension development normalized to maximum tetanic tension.

IMMOBILIZATION METHOD: Internal fixation with needles

RESULTS: Immobilization reduced aggregate EMG activity in the soleus, a slow muscle, to 5-15% of control and resulted in a shift from tonic to a more phasic (fast muscle) pattern of firing. After 4 wk of immobilization, speeding of the soleus mechanical properties was indicated by shortened contraction time, decreased tetanus-twitch ratio, increased maximum rate of development of tetanic tension, and decreased fusion during a 5 sec tetanus.

SOURCE: Journal of Physiology 201: 305-320, 1969

AUTHOR(S): Fischer, E. and V.W. Ramsey

EXPERIMENT TITLE: Changes in Muscle Proteins During Muscular Atrophy

SUBJECTS: Rabbits

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Four groups: 1) normal fresh gastrocnemius muscle; 2) normal fatigued (5 min faradic stimulation) gastrocnemius muscle; 3) gastrocnemius muscle after 5 or 28 days denervation; 4) gastrocnemius muscle after 5 or 21 days immobilization in a cast. Massage (5 min twice daily for 1 wk) and electrical stimulation were applied to some denervated and formerly cast muscles to prevent atrophy. Muscles were mashed, extracted with lithium chloride and fractionally precipitated at 6.6, 6.9, 7.2 and 7.5 pH. Measurements: the volume of precipitates, protein content of myosin solutions.

IMMOBILIZATION METHOD: Denervation; Plaster cast

RESULTS: Fatigue lowered solubility and changed the colloidal state of the myosin of the muscle. Denervation diminished the solubility of myosin and caused a decreased myosin content of the atrophied muscle. Immobilization caused similar changes in myosin as denervation, except that the amount of extracted myosin always declined less than in denervation atrophy of exactly the same weight loss. Electrical treatment after denervation and immobilization atrophy reversed the atrophy trend slightly, while massage reversed it to a greater degree.

SOURCE: Archives of Physical Therapy 25: 709-716, 1944

AUTHOR(S): Fischer, E. and V.W. Ramsey

EXPERIMENT TITLE: Changes in Protein Content and in Some
Physicochemical Properties of the Protein
During Muscular Atrophies of Various Types

SUBJECTS: White rabbits (3-5 kg)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: The gastrocnemius muscles used for investigation were either normal or had been submitted to immobilization (up to 5 wk) of the extended knee and foot by: 1) plaster of Paris cast reinforced by wiregauze; 2) tenotomy; or 3) nerve section. After ether narcosis, Achilles tendons were freed and connected with isometric levers. After strength measurements, rabbits were killed and gastrocnemii were dissected. Measurements: myosin content; myosin extraction; muscle weight; protein; collagen.

IMMOBILIZATION METHOD: Cast; Denervation; Tenotomy

RESULTS: Total protein concentration in gastrocnemius muscles diminished by about 14% during denervation atrophy of 22-30 days; during tenotomy, protein and weight loss were similar to denervation atrophy; and in cast immobilization, weight loss was nearly as large, but total protein was only about 1/3 the loss in the other restraints. Collagen concentration increased in all 3 restraints; noncollagenous protein content decreased by 13, 25 and 29%, and precipitable myosin per gm muscle decreased 11, 69 and 78% for cast, tenotomy, and denervation respectively. Hydrophilic power of the muscle increased by about 35% for cast and denervation, but decreased about 13% for tenotomy.

SOURCE: American Journal of Physiology 145: 571-582, 1946

AUTHOR(S): Fleming, D.E. and E.D. Bigler

EXPERIMENT TITLE: Relationship Between Photically Evoked After-Discharge Occurrence and Hippocampal EEG Rhythms in Restrained and Unrestrained Albino Rats

SUBJECTS: 20 Holtzman albino rats

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Subjects were anesthetized with pentobarbital sodium; indwelling silverball electrodes were implanted over the right and left visual cortices. Two groups: 1) restrained in a hammock - 10 rats, a reflecting hemicylinder was placed in front of hammock, a photo stimulator was placed 42.5 cm behind and slightly above the hemicylinder and used to deliver 10 μ sec light pulses; 2) unrestrained - 10 rats, single photic pulses were presented at a rate of 1/7 sec for 50 presentations; this procedure was repeated at least twice before the responses to the 26th through 50th light flashes were recorded. Measurements: photically evoked after-discharge (PhAD) occurrence; dorsal hippocampal EEG patterns.

IMMOBILIZATION METHOD: Hammock

RESULTS: The following distribution of hippocampal patterns were obtained from an examination of ongoing hippocampal EEG activity during the delivery of 25 photic stimuli: restrained, 12.0% small amplitude irregular waves (SIA); 77.6% large amplitude irregular slow waves (LIA); 10.4% rhythmical slow activity (RSA); unrestrained, 4.4% SIA, 56.0% LIA; 39.6% RSA. There was a moderately high correlation between hippocampal SIA and PhAD occurrence for both restrained (0.74) and unrestrained (0.81) conditions, even though these two conditions were significantly different with respect to SIA occurrence. Hippocampal LIA was low to moderately correlated with PhAD occurrence in both restrained (0.64) and unrestrained (0.55) conditions, which also were significantly different. RSA occurrence was independent of PhAD elicitation for both restrained and unrestrained conditions. PhADs were not elicited during hippocampal RSA episodes. Hippocampal RSA was highly correlated (0.87) with general motor activity. The restrained condition significantly enhanced the percentage of total PhAD elicitation.

SOURCE: Physiology and Behavior 13: 757-761, 1974

AUTHOR(S): Forsyth, R.P. and R. Baireuther

EXPERIMENT TITLE: Systemic Arterial Blood Pressure and Pulse Rate in Chronically Restrained Rhesus Monkeys

SUBJECTS: 13 Rhesus monkeys (3-4.5 kg)

AREA OF STUDY: Circulatory; Endocrine

OBJECTIVES: In title

PROTOCOL: Unanesthetized monkeys were surgically implanted with intra-arterial catheters. After recovery, each monkey was put in a restraining chair in a sound-proof, light-controlled booth and fed twice daily. The experiment lasted 35 wk. Measurements: arterial blood pressure (continuous); pulse rate; diurnal cycles; plasma epinephrine and norepinephrine levels.

IMMOBILIZATION METHOD: Chair

RESULTS: Blood pressures and pulse rates (avg 24 meas/day) were higher overall during the wk after surgery and introduction to restraining chair than subsequently (2-34 wk). The mean systemic arterial pressures (after 1st wk) varied from 117-136 mm Hg systolic; 71-84 mm Hg diastolic. The pulse rate varied from 118-160 beats/min. Mean plasma levels were 0.3 mg/liter for epinephrine; 0.9 mg/liter for norepinephrine.

SOURCE: American Journal of Physiology 212: 1461-1463, 1967

AUTHOR(S): Forsyth, R.P., A.S. Nies, F. Wyler, J. Neutze, and K.L. Melmon

EXPERIMENT TITLE: Normal Distribution of Cardiac Output in the Unanesthetized, Restrained Rhesus Monkey

SUBJECTS: 19 Male rhesus monkeys (3.1-6.8 kg)

AREA OF STUDY: Circulatory; Blood

OBJECTIVES: In title

PROTOCOL: Restraint: primate chairs, 13 monkeys sitting upright and 6 tilted to a supine position. Prior implantation of abdominal aortic catheter, and 2 additional catheters passed to the inferior vena cava and the left ventricle. Injections of microspheres of 50- to 55- μ mean diameter, labeled with either ^{125}I , ^{46}Sc , ^{85}Sr , or ^{51}Cr , were made over a 15 to 20 sec period in about 10 ml of saline through the catheter into the left ventricle. 24 to 48 hr after the first injection of the spheres, the monkeys were killed with an injection of sodium pentobarbital; major organs were removed. Measurements: cardiac output; hematocrit; radioactivity present in major organs; blood gases; pH; systemic arterial pressure.

IMMOBILIZATION METHOD: Chair

RESULTS: There were no significant differences between the measurements of the 13 sitting monkeys compared with the 6 supine monkeys in terms of base-line blood pressure and cardiac output. Hematocrits were unusually low; blood gases and pH fell within the normal range of reported values. Highest blood flow per 100 gm tissue in both groups was to the kidney, and then (in decreasing order) to the heart, spleen, and pancreas. The supine animals had significantly higher blood flows to the skin and kidney. Microsphere injections did not affect the circulatory variables studied and minimal numbers of spheres escaped the systemic microcirculation to enter the lungs, vena cava, or portal veins. In 2 other monkeys regional flow was determined after 2 additional injections with different nuclide labels 1 and 24 hr after the first; flow to most major organs remained within $\pm 16\%$ of the base-line measurement.

SOURCE: Journal of Applied Physiology 25: 736-741, 1968

AUTHOR(S): Fudema, J.J., J.A. Fizzell, and E.M. Nelson

EXPERIMENT TITLE: Electromyography of Experimentally Immobilized Skeletal Muscles in Cats

SUBJECTS: 10 Young adult cats, male and female

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: The hind limbs of the cats were immobilized under pentobarbital anesthesia. Under aseptic conditions, partially threaded stainless steel pins were screwed through both cortices of the femur and metatarsus. The knee and ankle joints were fixed by orienting and externally stabilizing the pins in a fixed pattern with stainless steel clamps and bars. The limbs were set so that the anterior tibial muscle was not on stretch to minimize muscle spindle discharge. An electromyograph was used to measure the action-potential output of anterior tibial muscles. Recordings were made of the maximum integrating meter response of the muscle to a standardized supramaximal electrical stimulus (1.0 ma applied for 1.0 msec) applied percutaneously to the common peroneal nerve while the animals were uniformly anesthetized. Bilateral examinations made every 4 days for 101 days.

IMMOBILIZATION METHOD: External fixation with pins, clamps and bars

RESULTS: The electromyographic data obtained from the anterior tibial muscles showed a continually decreasing electrical output during the immobilization period. No statistically significant difference was found between the response of the right and left sides. A definite reduction in muscle mass was observed in all 10 animals between 40-50 days of the experiment. At 101 days the atrophy of the muscle mass was very marked with bony structures becoming prominent. On autopsy the skeletal muscles appeared pale and atrophic.

SOURCE: American Journal of Physiology 200: 963-967, 1961

AUTHOR(S): Furry, D.E.

EXPERIMENT TITLE: The Effect of Vibration and Restraint on Body Weight and Survival of the Albino Rat

SUBJECTS: Male Sprague-Dawley rats 12-16 wks old (200-400 gm)

AREA OF STUDY: Body mass

OBJECTIVES: In title

PROTOCOL: Four groups of 25 each: 1) restraint and vibration at fixed frequency and displacement until cessation of vital functions; 2) restraint and vibration for 30 min; 3) restraint only (non-vibrated) for 30 min; and 4) non-restraint, vibration only, 6 hr. All vibration exposures were conducted at a fixed frequency of 25 cps with a displacement of 0.25 inch. Diet: Purina Laboratory Chow. Food and water withheld during exposure. Measurements: excremental production, survival time.

IMMOBILIZATION METHOD: Neck collar

RESULTS: Whole body vibration of restrained rats at a constant frequency and displacement effected a lethal result with sufficient exposure time. The major pathological finding resulting from lethal whole body vibration was primarily pulmonary. Hemorrhages of the gastrointestinal tract and myocardial wall were frequently found in group 1. No evidence of gross pathology was apparent in groups 2, 3 and 4. Exposure to vibration stress for 30 min produced non-lethal stress without significant anatomical damage. Mean survival time for group 1 was 116 min; no animals in the three remaining test groups died as a result of exposure to vibration stress. There was a loss of body weight during the periods of prolonged exposure to vibration.

SOURCE: U.S. Naval School of Aviation Medicine, Pensacola, Florida, September 19, 1963, 8 pp. (Research Report No. 5; Project MR005.13-1002)

AUTHOR(S): Galaktinov, V.G. and A.S. Ushakov

EXPERIMENT TITLE: Effect of Hypokinesia on Cellular and Humoral Indices of Antibody Formation in Rats

SUBJECTS: 165 Wistar rats

AREA OF STUDY: Circulatory; Blood

OBJECTIVES: In title

PROTOCOL: Five experimental periods: 2, 9, 45, 45 and 90 days. There were control and experimental rats for each period. Rats in the control group were kept in ordinary vivarium cages whereas rats in the experimental group were placed in special cages. Each cage was 7.5 cm high. The unit was in turn divided by metal partitions into compartments 5.5 cm wide. Each compartment held one rat. The animals were immunized after termination of hypokinesia. Both the control and experimental rats were injected iv with 1 ml of a 50% suspension of sheep erythrocytes. Blood was taken from animals which died on the 5th day after immunization for analyzing the hemolysin titers and the spleen was extracted for determining the number of antibody-producing cells in the total number of nuclear cells in the spleen. In the two 45-day experiments the hemolysis titers and the number of antibody-producing cells in the spleen were determined on the 3rd, 5th, 10th and 20th days after immunization.

IMMOBILIZATION METHOD: Compartment

RESULTS: The number of antibody-producing cells in the spleen and hemolysin titers of hypokinetic animals was dependent on exposure time. Two- and 9-day exposures resulted in an inhibition of antibody formation, that is, a decrease in cellular and humoral indices; 45-day exposure improved the antibody-producing function. A longer exposure (90 days) caused repeated inhibition of antibody production.

SOURCE: Space Biology and Medicine 3(5): 59-65, 1969

AUTHOR(S): Galaktionov, V.G., A.S. Ushakov, and S.S. Brantova

EXPERIMENT TITLE: Influence of Hypodynamia and Alimentary Protein Deficiency on the Proliferation Rate of Antibody-Forming Cells in Rats

SUBJECTS: Male Wistar rats

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: Four groups: 1) hypodynamic in cages and a diet containing 18% protein (control diet); 2) hypodynamic and a diet containing 3.2% protein (experimental diet); 3) kept in vivarium cages and 18% protein diet; 4) kept in vivarium cages and 3.2% protein diet. After 45 days, the rats were immunized iv with 1 ml of a 50% sheep-erythrocyte suspension. Five days later, blood was taken for analysis of hemolysins, the spleen was removed, and the amount of antibody-forming cells in the entire spleen was determined.

IMMOBILIZATION METHOD: Cage

RESULTS: Hypodynamia with an optimum dietary protein content led to a marked increase in the proliferation rate of antibody-forming cells, while hypodynamia and dietary protein deficiency sharply reduced it. The proliferation rate of antibody-forming cells in these animals was less by a factor of 5-6 than in the rats that received the control diet and were kept in hypodynamic chambers and less by a factor of 3-3.5 than in the animals that received the control diet and were kept under normal conditions.

SOURCE: Eksperimental'nye Issledovaniya Gipokinezii, Izmenennoi Gazovoi Sredy, Uskorenii, Peregruzok i Drugikh Faktorov (ed. by V.V. Parin et al), 1968, pp. 12-14.

AUTHOR(S): Ganguly, A.k., S.K. Lal, S.D. Nishith, and S.K. Sreepathi Rao

EXPERIMENT TITLE: The Influence of Blood Sugar Level on the Quantitative Assessment of Ulcers Produced by Restraint Method in the Stomach of Albino Rats

SUBJECTS: 40 Albino rats (82-126 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Four groups of 10 rats each: 1) controls; 2) restraint only - 20 hr; 3) hyperglycemia and restraint - hyperglycemia induced by iv alloxan monohydrate 70 mg/kg. 4 hr following alloxan, rats were allowed access to food over the next 48 hr, then fasted for 48 hr before 20 hr of restraint; 4) hypoglycemia and restraint - induced by iv soluble insulin, 0.1 to 0.12 units. All animals were fasted for 48 hr prior to experimentation. At the end of each experiment rats were anesthetized with ether and stomachs were removed and examined. Measurements: incidence and index (extent of) of ulceration; pH of gastric content; blood sugar.

IMMOBILIZATION METHOD: Wire screen fastened with staples

RESULTS: Incidence of ulceration: restraint only, 80% of the rats developed ulcers of varying extent; hyperglycemia and restraint, 10% only, with limited extent; hypoglycemia and restraint, 100% developed ulcers of varying extent.

SOURCE: Indian Journal of Medical Research 57(2): 295-299, 1969

AUTHOR(S): Ganguly, A.K. and O.P. Bhatnagar

EXPERIMENT TITLE: Effect of Bilateral Adrenalectomy on Production of Restraint Ulcers in the Stomach of Albino Rats

SUBJECTS: 18 Albino rats (126-278 gm)

AREA OF STUDY: Digestive; Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) bilateral adrenalectomy, normal food and .85% saline, food deprivation for 36-40 hr, 10 cc 25% glucose, 20-22 hr restraint in galvanized steel window screen fastened with staples, 2 cc ferric chloride, sacrificed 1 hr later, and stomachs examined; 2) mock adrenalectomy, normal food and water, water during food deprivation; all other conditions the same as for group 1.

IMMOBILIZATION METHOD: Galvanized steel window screen

RESULTS: In the vagus-intact bilaterally adrenalectomized rats, the ulcer index dropped to .016 from .11 in group 2.

SOURCE: Canadian Journal of Physiology and Pharmacology 51: 748-750, 1973

AUTHOR(S): Gass, G.H., W.M.W. Yau, and M.F. Nudd

EXPERIMENT TITLE: Glucose and Fructose Absorption in Chronically Immobilized Rat

SUBJECTS: Male rats (255±7 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental rats were placed in cages which increased linearly with body weight as well as body volume. The period of restraint ranged from 5 to 25 wk. Rats were food deprived 24 hr prior to experiments. Diets: food and water ad libitum. Measurements: body weight; glucose absorption; fructose absorption.

IMMOBILIZATION METHOD: Cage

RESULTS: Glucose absorption studies showed no significant differences in the transport system, but fructose studies showed a significant increase in sugar absorption in restrained rats throughout the 25-wk period. Restrained animals showed a decreased growth rate.

SOURCE: Comparative Biochemistry and Physiology 41A(1): 225-233, 1972

AUTHOR(S): Gayevskaya, M.S., L.M. Slez, and N.A. Ilyushko

EXPERIMENT TITLE: Effect of Hypokinesia on the Protein Composition of Skeletal Muscles

SUBJECTS: White rats (180-250 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control (22 rats); 2) experimental animals (18 rats) kept in individual plastic cages which considerably restricted their mobility. Rats were decapitated on day 30 or 60 and triceps surae and quadriceps femoris were removed. Diet: synthetic. Measurements: protein; water.

IMMOBILIZATION METHOD: Cage (plastic)

RESULTS: Rats did not develop hypokinesia immediately after restraint, but only after extinction of the "freedom reflex". During muscular activity prior to hypokinesia, sarcoplasmic protein content decreased in hind limb muscles and myofibrillar protein quantity increased. Hypokinesia reduced the content of myofibrillar protein content in skeletal muscles but produced no changes in sarcoplasmic protein concentration or composition.

SOURCE: Space Biology and Medicine 4(4): 34-39, 1970

AUTHOR(S): Gayevskaya, M.S., I.I. Ivanov, N.V. Karsanov, N.B. Gabadze, V.A. Magaldadze, N.P. Mikhaleva, and Y.A. Nosova

EXPERIMENT TITLE: Effects of Weightlessness and Hypokinesia on Contractility of Bundles of Glycerin-Treated Rat Muscle Fibers

SUBJECTS: Male Wistar rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Four groups: 1) weightlessness - 22 day space flight, skeletal muscles removed 2 and 27 days after return; 2) ground-based experiment - animals kept for 22 days in a mock-up of spacecraft, with simulation of all conditions except weightlessness, skeletal muscles removed 2 and 27 days after conclusion; 3) hypokinesia rats were placed in a stand with ability to move their front legs, head and tail for 50 days; 4) controls for groups 1, 2 and 3. Pieces of muscle with mixed fibers, excised in the direction of the myofibrils, were extracted in 50% aqueous glycerin solution at 4°C for 24 hr; just prior to measuring contractility of fibers, pieces of glycerin-treated muscle tissue were transferred into a 15% aqueous solution of glycerin for 1 hr at 4°C. Measurements: development of tension.

IMMOBILIZATION METHOD: Stand

RESULTS: There were no reliable differences in tension developed by bundles of muscle fibers from rats taken 2 and 27 days after flight, and from control animals, as well as between ground-based subjects and controls. Fifty-day hypokinesia did not elicit changes in magnitude of tension developed by muscle fiber bundles of the gastrocnemius and femoral quadriceps, as compared to the control.

SOURCE: Space Biology and Aerospace Medicine 12(4): 98-101, 1978

AUTHOR(S): Gazho, M., M. Stanislavova, V. Sabo, K. Vodya, E. Ginter,
and M. Yurani

EXPERIMENT TITLE: Effect of Accelerations, Additional Weight Load And
Hypokinesia on the Metabolism of Proteins in the
Japanese Quail (*Coturnix Coturnix Japonica*) I. Effect
on Muscle Composition

SUBJECTS: 16 Japanese quail, 12 mo old

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Four groups: 1) controls; 2) hypokinesia in wire cages; 3)
excess weight load; 4) exposed to an acceleration of 3 G. The birds were
exposed to the above effects 1-6 hr daily for 8 days. The animals were
then sacrificed by decapitation; the blood was drained and the liver,
kidneys, chest and pelvic muscles were extracted. Measurements: total
proteins, sarcoplasmatic proteins, DNA and RNA, cholesterol and esterified
fatty acids in the chest and pelvic muscles; total lipids in the pelvic
muscles; corticosterone level in blood plasma.

IMMOBILIZATION METHOD: Wire cage (floor area = 46.7 cm²)

RESULTS: Weight load and acceleration decreased and hypokinesia increased
the content of total proteins in the pelvic muscles. During the exposure to
acceleration and hypokinesia the content and the portion of sarcoplasmatic
proteins decreased and during exposure to weight load increased significantly.
Acceleration did not exert a significant effect on the RNA and DNA content
in the muscles. The content of esterified fatty acids increased under the
influence of acceleration and hypokinesia and decreased significantly under
the influence of added weight.

SOURCE: Space Biology and Medicine 9(6): 19-26, 1975

AUTHOR(S): Gazho, M., J. Iankela, W. Sabo, and K. Bodia

EXPERIMENT TITLE: Effects of Accelerations, Additional Weight Load and Hypokinesia on Protein Catabolism in the Japanese Quail (*Coturnix Coturnix Japonica*)

SUBJECTS: Japanese quail

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Four groups: 1) controls; 2) hypokinesia in wire cages; 3) excess weight load; 4) exposed to an acceleration of 3 G. The birds were exposed to the above effects 1-6 hr daily for 8 days. The animals were then sacrificed. Measurements: glutamine dehydrogenase activity in liver, kidneys, and muscles of iliotibialis anterior, medialis and posterior, fibularis superficialis, gastrocnemius; uric acid; nitrogen.

IMMOBILIZATION METHOD: Wire cage (floor area = 46.7 cm²)

RESULTS: Glutamate dehydrogenase activity of the liver was reliably higher in birds submitted to centrifugation vs. that of controls and hypokinetic birds, but not those exposed to an additional weight load. Also, in the liver there were statistically reliable changes in xanthine dehydrogenase activity in quail submitted to centrifugation and weight load, but decreased as a result of hypokinesia. Xanthine dehydrogenase activity of the kidney, converted to organ mass, was reliably higher in birds exposed to an additional weight load vs. controls, hypokinetic birds, and birds exposed to centrifugation vs. hypokinetic birds. Xanthine dehydrogenase activity was low in the muscles of the extremities, with no statistically reliable difference between groups; weight loaded birds showed a tendency toward elevation of this index. There were no differences in nitrogen and uric acid excretion.

SOURCE: Space Biology and Medicine 11(1): 39-41, 1977

AUTHOR(S): Geiser, M. and J. Trueta

EXPERIMENT TITLE: Muscle Action, Bone Rarefaction and Bone Formation

SUBJECTS: 82 Rabbits (3-12 mo old)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Six experiments: 1) Partial excision of calcaneal tendon (40 rabbits). A piece of the right tendo calcaneus was excised 2 centimeters proximal to the attachment of the tendon; the left tendon served as a control. 2) Immobilization in plaster of Paris (22 rabbits) of the right hind leg. 8 animals were left free after 3 to 4 wk of plaster immobilization. 3) Immobilization in plaster of Paris and faradic stimulation (4 rabbits). Immobilized as in the previous experiment, had faradic stimulation applied twice a day in 2 animals and 8 times a day in the other 2 for 4 wk. 4) Effect of fracture together with plaster immobilization (14 rabbits). An osteotomy was performed after which the fragments were stabilized by internal fixation with wire and immobilizing the limbs in plaster. 5) Resection of peritendinous tissue about the calcaneal tendon (2 rabbits). The peritendinous tissue was excised from the tendo calcaneus without cutting the tendon itself. The animals were left free after the operation. 6) Bone reconstruction - effect of mobilization after removal of plaster (8 rabbits). After immobilization of a hind limb for 3 or 4 wk, the animals were left free.

IMMOBILIZATION METHOD: Plaster of Paris

RESULTS: Rarefaction of the calcaneum was caused in all the animals soon after it was relieved from muscular compressing forces. New bone was generated when the calcaneum was subjected again to the stresses and strains of muscle contraction. Bone rarefaction was characterized by an increase in the vascularity of the bone; this increase ceased when the bone reached its final precarious bone density.

SOURCE: Journal of Bone and Joint Surgery 40-B(2): 282-311, 1958

AUTHOR(S): Gerety, D.C. and P.H. Guth

EXPERIMENT TITLE: Restraint-Induced Gastric Erosions: Role of Acid Back Diffusion

SUBJECTS: Male white Wistar rats (160-200 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) rats restrained by wrapping them in wire mesh for 1, 4 or 24 hr. Rats were fasted 48 hr prior to the experiment; rats to be restrained for 24 hr were fasted for 24 hr. One hr prior to sacrifice and restraint cessation, the pylorus was ligated and a test solution of either H^+ 100 mEq/liter or isotonic saline was instilled into the stomach. Diet: water ad libitum. Measurements: gastric content; Na^+ , K^+ , Cl^- , H^+ , and $^{51}CrCl_3$.

IMMOBILIZATION METHOD: Wire mesh

RESULTS: All rats showed back diffusion with no difference between control and restrained rats. Mucosal lesions were correlated with the presence of hydrogen ions and length of restraint stress, but not with any change in hydrogen ion back diffusion. In restrained pylorus-ligated rats, there was a marked decrease in hydrogen ion secretion.

SOURCE: American Journal of Digestive Diseases 17: 1012-1018, 1972

AUTHOR(S): Gerus, A.I.

EXPERIMENT TITLE: The Effect of Hypodynamia on the Structure of the Intraorganic Blood Vessels and the Capacity of the Blood Stream in the Diaphragm of White Rats

SUBJECTS: 36 White rats (180-310 gm)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 30 rats placed in body-fitting cages for 7-90 days; 2) 6 controls. The vessels were injected with a 50% aqueous solution of black dye. Tissue specimens were excised from the diaphragm and contrasted or stained.

IMMOBILIZATION METHOD: Cage (body fitting)

RESULTS: The capacity of an intraorganic bloodstream in 1 mm of muscle mass in the controls was 12,147,059 mk^2 , and in a tendinous center the capacity was 151,949,277 mk^2 . After 7 days of hypodynamia, the capacity of the bloodstream dropped by 36% and continued to drop, resulting in the death of capillaries by the end of the 2nd wk. In prolonged hypodynamia, the capacity of the vascular system of the diaphragm increased at the price of a dispersion of venous vessels.

SOURCE: Vestsi Akademii Navuk BSSR: Seryia Biialahichnykh Navuk No.3: 94-98, 1974

AUTHOR(S): Gisler, R.H.

EXPERIMENT TITLE: Stress and Hormonal Regulation of the Immune Response in Mice

SUBJECTS: Mice

AREA OF STUDY: Endocrine; Blood

OBJECTIVES: In title

PROTOCOL: Six groups: 1) acceleration; 2) ether anesthesia; 3) restraint - 6 hr in perforated tubes (30 x 115 mm); 4) overcrowding - produced by keeping mice in groups of 20 for 72 hr in cages adapted to allow approximately 25 cm² of floor space per mouse; 5) hormone regulation - injection of adrenocorticotrophic hormone (ACTH); 6) controls. Spleen cell suspension cultures were prepared. Diazepam and desipramine were also administered under ether/restraint stresses. In vitro reactivity of spleen cells from hypophysectomized animals was also studied, together with pretreatment with somatotrophic hormone (STH). Measurements: plaque-forming cells (PFCs); effect of diazepam and desipramine on ether stress and restraint stress; plasma corticosterone; immune response to sheep red blood cells (SRBC) of the cell types required for response, i.e., macrophages, T-cells, B-cells; lymphocyte distribution.

IMMOBILIZATION METHOD: Perforated tube (30 x 115 mm)

RESULTS: Cultures from acceleration and ether stress groups displayed a significantly decreased capacity to generate PFCs; normal responsiveness was restored within 72 hr. Cultures from restraint and overcrowding groups reacted poorly to SRBC. Repeated administration of ether stress (4 times a day for 3 days) no longer had any immunosuppressive effect. Pretreatment with diazepam of cell donors prior to acute stress antagonized the immunosuppressive effect of restraint but was ineffective against the consequences of ether anesthesia. Desipramine did not interfere with either type of stress response. Exposure to stress or ACTH increased plasma corticosteroid levels. This was associated with a decreased immune reactivity of their spleen cells in vitro. Macrophages and B-cells from normal mice reactivated unresponsive spleen cell cultures. Addition of macrophages, B, or T-cells alone, or combinations of T-cells with macrophages or B-cells, had no restorative effect. Restraint stress significantly increased the homing of Cr-labeled lymph node cells from normal nu/+ mice (B and T-cells) to spleen and bone marrow. Homing of nu/nu lymph node cells (B-cells) to lymph nodes and spleen was decreased under stress, and an increased proportion of cells was found in the liver. Hypophysectomy of cell donors resulted in a persistent depression of immune responsiveness, which was restored by pretreatment with STH. Exogenous STH interfered with the effect of increased endogenous corticosterone.

SOURCE: Psychotherapy and Psychosomatics 23: 197-208, 1974

AUTHOR(S): Gitilis, V.S. and T.V. Vorob'yeva

EXPERIMENT TITLE: Structure of Spinal Cord Capillaries in Hypokinesia

SUBJECTS: 44 Cats, 2-3 yr old

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 35 cats, hypokinetic for 30-40 days for light-microscopy study; 2) 9 cats, hypokinetic for 30-40 days for electron-microscopy study. All cats were immobilized in cages completely restricting mobility of the hind legs. Pigments were introduced into the circulatory system, the animals were killed and segments of the brain and spinal cord were excised and prepared for microscopy. Measurements: area of neuronal profile field, number of capillaries, their length and width, distance from the body of nerve cells, area of the capillary bed and index of capillary-neuronal relationships.

IMMOBILIZATION METHOD: Cage

RESULTS: Following hypokinesia, no significant reconstruction of the structural organization of the terminal links in the microcirculatory apparatus was observed. The capillaries reacted to hypokinesia by undergoing stenosis, and a considerable decrease in the area of the capillary bed. The ratio of the area of the capillary bed to the area of the neuron profile field was reduced by half. There was significant thickening of the basal membrane of the capillaries and vacuolization of the cytoplasm of the endothelial cells. There was an accumulation of mitochondria in glial cells contacting the wall of the capillary.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 63(11): 38-41, 1977

AUTHOR(S): Glavin, G.B. and A.A. Mikhail

EXPERIMENT TITLE: Role of Gastric Acid in Restraint-Induced Ulceration
in the Rat

SUBJECTS: 50 Male Sprague-Dawley rats, 100 days old (250±10 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Five groups: 1) 72-hr food deprivation plus 72-hr restraint;
2) same as group 1 plus oral intubation force-feeding of 300 mg (5 ml)
aluminum hydroxide once every 24 hr during deprivation and restraint;
3) same as groups 1 and 2 but force-fed only during food deprivation;
4) same as groups 1, 2 and 3 but force-fed only during restraint; and
5) controls. Following restraint in Plexiglas cages all rats were killed
by ether overdose and their stomachs removed. Measurements: ulceration;
pH.

IMMOBILIZATION METHOD: Cage (plexiglas)

RESULTS: Aluminum hydroxide, when given during food deprivation, markedly
reduced the incidence and severity of rumenal and glandular ulcers; Groups
2 and 3 had the lowest incidence and severity.

SOURCE: Physiology and Behavior 17: 777-780, 1976

AUTHOR(S): Golarz de Bourne, M.N., G.H. Bourne, H.M. McClure, and M.E. Keeling

EXPERIMENT TITLE: The Pathology of Isolation and Inactivation of Monkeys

SUBJECTS: Rhesus macaque monkeys

AREA OF STUDY: Metabolism and Energy Exchange; Blood

OBJECTIVES: In title

PROTOCOL: Five groups: 1) 4 monkeys in complete individual isolation for 1 yr; 2) 6 monkeys in partial isolation for 2-6 mo; 3) 1 monkey with limbs inactivated in a plaster cast for 6 mo; 4) 1 monkey with limbs immobilized with metal pins in the joints for 6 mo; 5) 1 monkey in a whole body cast and kept in horizontal positions for 5 mo. At the termination of each experiment the animals (except 3) were autopsied. Measurements: a variety of organs and tissues were taken for histopathological, histochemical, and electron microscopic study; in some cases, blood and bone marrow were also analyzed.

IMMOBILIZATION METHOD: Plaster cast; Metal pins

RESULTS: After individual complete isolation for 1 yr, there was an accumulation of fat in the liver, large inactive thyroid follicles, pathological changes in the skeletal muscles (2 animals) and no significant changes in the blood chemistry. After 2-6 mo in partial isolation, there was more connective tissue found in the heart; fewer tubules with active spermatogenesis in the animal isolated for 6 mo than 2 mo; and muscles appeared normal. No profound changes were found in the muscles of the limb inactivated by a plaster cast for 6 mo; there was severe muscle atrophy in the limb inactivated by immobilization with a metal pin. Monkeys in whole body casts showed an accumulation of fat in various organs; the heart and the liver were most affected. Creatine phosphokinase increased 2½ times, alkaline phosphatase activity increased, sodium and potassium levels remained normal. There was a 10% drop in the red cell count, a 43% increase in white cells, a 14% drop in hematocrit and a 22% increase in hemoglobin.

SOURCE: Revue de Medecine Aeronautique et Spatiale 12(46): 355-357, 1973

AUTHOR(S): Goldenberg, M.M.

EXPERIMENT TITLE: Study of Cold + Restraint Stress Gastric Lesions
in Spontaneously Hypertensive, Wistar and Sprague-
Dawley Rats

SUBJECTS: Male Spontaneously Hypertensive, Wistar, Sprague-Dawley rats
(210-310 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) Sprague-Dawley (SD), Spontaneously Hypertensive (SH) and Wistar rats were fasted for 27 hr then each was immobilized in a metal can with an opening for the head and closed with a rubber stopper with an opening for the tail. Adhesive tape was wrapped lightly around the neck of the animal to restrict head movement and was used to secure the stopper. They were placed in the cold (7°C) for 3 hr before ether overdose; 2) fasted control rats of the 3 strains. The stomachs were removed and examined for hemorrhagic lesions. Measurements: percentage of rats with lesions; average lesions/stomach.

IMMOBILIZATION METHOD: Metal can (11.88 x 6.25 cm) and tape

RESULTS: The incidence of gastric lesions after cold + restraint was found to be significantly greater in the SD rat than SH or Wistar rats. The incidence of gastric lesions was significantly higher in the SH than in the Wistar rat. After cold + restraint, the SD and SH rats were estimated to have the same average lesions/stomach values, which were significantly higher than in Wistar rats.

SOURCE: Life Sciences 12(Pt.1): 519-527, 1973

AUTHOR(S): Goldenberg, M.M.

EXPERIMENT TITLE: Stress-Induced Gastric Lesions in Spontaneously Hypertensive Rats: Involvement of Autonomic Neurotransmitter Substances

SUBJECTS: Spontaneously Hypertensive rats, Wistar rats

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Three series: I - Spontaneously Hypertensive (SH) and normotensive Wistar rats were vagotomized 7 days before being subjected to a 27 hr fast and 3 hr immobilization at 70°C. Each was placed in a metal can with an opening for head and closed with a rubber stopper with a hole for the tail. Adhesive tape was wrapped lightly around the neck to restrict movement and secured the stopper to the can. II - Reserpine (1 mg/kg ip) was administered to intact or vagotomized rats 27 hr before cold + restraint stress as in Series I; III - Intact or vagotomized fasted rats were pre-treated with reserpine (1 mg/kg ip) or administered levodopa (1 gm/kg sc) or both, 27 hr before stress. Controls were maintained for all series. Measurements: gastric ulceration.

IMMOBILIZATION METHOD: Metal can and adhesive tape

RESULTS: Treatment with vagotomy plus reserpine, levodopa or levodopa plus reserpine significantly decreased the number and incidence of lesions. Nonhemorrhagic gastric ulcers were observed in SHR after vagotomy or vagotomy plus reserpine. In normotensive Wistar rats, vagotomy and levodopa failed to affect stress-induced lesions. Reserpine increased the number and frequency of lesions while vagotomy and levodopa abolished responses to reserpine. Nonhemorrhagic gastric ulcers were absent in normotensive rats.

SOURCE: American Journal of Digestive Diseases 19(4): 353-360, 1974

AUTHOR(S): Goldman, A.D. and W.C. Yakovac

EXPERIMENT TITLE: The Enhancement of Salicylate Teratogenicity by Maternal Immobilization in the Rat

SUBJECTS: Female Sprague-Dawley rats, 8-9 wk old (185-215 gm)

AREA OF STUDY: Pharmacology; Reproduction

OBJECTIVES: In title

PROTOCOL: Seven-day pregnant rats were divided into 2 groups: 1) salicylate controls; 2) immobilized and administered sodium salicylate sc on day 10. The pregnant rats were immobilized on a 2.5 x 25 cm board with 6 sets of 4 mirror holders so spaced that the paws of each rat could be taped. Controls were food- and water-deprived during the period that experimental rats were immobilized. Fetuses were grossly examined after cesarean section on day 20. Measurements: maternal death; maternal morbidity; fetal mortality; fetal morbidity; fetal abnormality, salicylate toxicity.

IMMOBILIZATION METHOD: Board with mirror holders and adhesive tape

RESULTS: Immobilization alone markedly reduced fetal growth and markedly increased the production of anomalies in proportion to salicylate dose and restraint duration. Maternal restraint raised the total rate and changed the pattern of anomalies produced by salicylate to a relative predominance of larger-sized defects involving multiple systems along the whole of either or both the dorsal or ventral midlines. The mechanism of action of restraint in enhancing salicylate teratogenesis is not clear.

SOURCE: Journal of Pharmacology and Experimental Therapeutics 142: 351-357, 1963

AUTHOR(S): Goldspink, D.F.

EXPERIMENT TITLE: Changes in Size and Protein Turnover of Skeletal Muscle After Immobilization at Different Lengths

SUBJECTS: Young male rats (approx 60 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) immobilized in either extended or flexed positions of the ankle joint using plaster of Paris casts. Measurements: average rates of protein break-down and protein synthesis in isolated intact soleus and digitorium longus muscle.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: Both the soleus muscle and the extensor digitorium longus muscle grew more rapidly when immobilized in the lengthened position, which was accompanied by an accumulation of muscle proteins, the result of increased rates of protein synthesis. In the flexed position, both muscles underwent atrophy, in which rates of protein synthesis decreased and protein break-down increased.

SOURCE: Journal of Physiology 263(2): 269P-270P, 1976

AUTHOR(S): Goldspink, D.F.

EXPERIMENT TITLE: The Influence of Immobilization and Stretch on Protein Turnover of Rat Skeletal Muscle

SUBJECTS: Male CD rats (50-60 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: The ankle joint of 1 hind limb was immobilized either in an extended or flexed position by application of a cast for 1-7 days. The contralateral limb served as control. After immobilization the animals were killed by cervical dislocation and the appropriate muscles rapidly dissected out. Measurements: average rates of protein synthesis and break-down in soleus and extensor digitorum longus (EDL) muscles, by measurement of ^{14}C tyrosine after 2 hr incubations, muscle wet weight.

IMMOBILIZATION METHOD: Cast

RESULTS: When immobilized in a shortened position the soleus and EDL muscles underwent atrophy, showing net losses of tissue protein. When immobilized in a lengthened position, they grew due to increased protein synthesis; DNA synthesis, DNA and RNA concentrations rose in the immobilized tissues.

SOURCE: Journal of Physiology 264(1): 267-282, 1977

AUTHOR(S): Goldspink, D.F.

EXPERIMENT TITLE: The Influence of Activity on Muscle Size and Protein Turnover

SUBJECTS: Male rats, CD strain (50-60 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Immobilization: 2 days, cast applied to the ankle joint of hind limb in an extended position, with the soleus and plantaris muscles held in a shortened position, and the anterior tibialis and extensor digitorum longus (EDL) in a lengthened position. After immobilization the animals were either killed or freed of their casts to allow normal muscle activity during the recovery phase of 7 days. The contralateral limb served as control. In experiments designed to study the significance of de novo synthesis of RNA or DNA during recovery, each animal received daily injections of either 1.5 mg actinomycin D, or 100 mg 5-fluorodeoxyuridine per kg body wt, respectively. Measurements: wet muscle weight; average rate of protein synthesis and protein breakdown; RNA/DNA synthesis.

IMMOBILIZATION METHOD: Cast

RESULTS: Two days immobilization caused the following change in the wet weights of the muscle studied: the soleus and plantaris lost weight; the EDL grew and the anterior tibialis had no significant change. These changes in muscle size were accompanied by appropriate gains or losses in tissue protein. The soleus and plantaris muscles grew as a function of time after the return of normal activity. Activity stimulated protein synthesis and inhibited protein breakdown of the soleus muscle. Blockage of de novo synthesis of RNA, but not DNA, severely restricted the normal, rapid enhancement of protein synthesis after the return of activity. In the EDL, activity after immobilization lifted the growth-promoting influences, and a lower rate of protein turnover was restored. Changes in EDL RNA concentrations followed a similar pattern; the higher RNA concentrations of the immobilized EDL slowly returned to normal during activity. RNA concentrations increased during recovery.

SOURCE: Journal of Physiology 264(1): 283-296, 1977

AUTHOR(S): Goldspink, D.F.

EXPERIMENT TITLE: A Comparative Study of the Effects of Denervation, Immobilization, and Denervation With Immobilization on the Protein Turnover of the Rat Soleus Muscle

SUBJECTS: Rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Three groups: 1) denervation; 2) immobilization, of innervated soleus muscle in a shortened position using a plaster cast; 3) immobilization of denervated soleus muscle in a shortened, unstretched position. Measurements: degree of atrophy; protein turnover.

IMMOBILIZATION METHOD: Cast; Denervation

RESULTS: Both immobilization and denervation alone gave rise to smaller muscle with less intracellular protein. The immobilized soleus continued to waste with time, while the denervated tissue exhibited signs of renewed growth after 7 and 10 days. Protein synthesis was higher in the denervated muscle than in the innervated controls; with a decreased rate of synthesis and increased rate of protein breakdown in immobilized muscle. Immobilization and denervation together produced a greater atrophy than that produced by either alone.

SOURCE: Journal of Physiology 280: 64P-65P, July 1978

AUTHOR(S): Gondos, B., R. Zemjanis, and A.T.K. Cockett

EXPERIMENT TITLE: Ultrastructural Alterations in the Seminiferous Epithelium of Immobilized Monkeys

SUBJECTS: 4 Macaca nemestrina monkeys

AREA OF STUDY: Reproduction

OBJECTIVES: In title

PROTOCOL: The monkeys were placed in specially designed suits and suspended in couch-like frames. They were placed in an upright sitting position during the daytime and a horizontal resting position at night. Testicular specimens were obtained prior to and after 7, 10 and 14 days of immobilization, and 30 and 60 days after release from couch. Initial biopsies were taken from the cranial surface of the right testis. Subsequent specimens were obtained from alternate testes and surfaces in sequence. Diet: fresh fruit, vegetables, nuts, bread and monkey pellets given ad libitum once a day.

IMMOBILIZATION METHOD: Specially designed suits and couch-like frames

RESULTS: Testicular biopsies taken after immobilization showed progressive degeneration and disappearance of spermatocytes and spermatids. Variations in size and shape of the spermatid nuclei were commonly seen during immobilization. Autophagic vacuoles were occasionally seen in the cytoplasm of normal spermatocytes. Changes in spermatogonia were of limited degree.

SOURCE: American Journal of Pathology 61(3): 497-505, 1961

AUTHOR(S): Gorbunova, A.V.

EXPERIMENT TITLE: Effect of Restricted Mobility on RNA Content and Nucleotide Composition and on Protein Content in Motoneurons of Spinal Cord Anterior Horns

SUBJECTS: 70 Male rats (260-300 gm)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) immobilized in a cage. The spinal cord on the level of the intumescentia lumbalis was taken from the experimental and control rats simultaneously on days 1, 3, 5, 7, 10, 14 and 30. Measurements: RNA and protein content in the spinal cord motoneurons; nucleotide composition of RNA.

IMMOBILIZATION METHOD: Cage

RESULTS: There was a decline in the RNA content in the motoneurons of the spinal cord anterior horns on the 1st, 3rd and 5th day of hypokinesia which returned to the initial level by the 7th day of the experiment. In the further periods of the experiment no changes were found in the RNA content. On the 3rd and 5th day of hypokinesia a reduction occurred in the protein content of the nerve cell. The cytoplasm nucleotide composition of the total cellular RNA at all periods of hypokinesia remained unchanged and was characteristic of ribosomal RNA.

SOURCE: Doklady Akademii Nauk SSSR 199(4): 976-979, 1971

AUTHOR(S): Gorbunova, A.V.

EXPERIMENT TITLE: RNA Content in Spinal Cord Motoneurons During Hypokinesia

SUBJECTS: 70 Male albino rats (260-300 gm)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) immobilized in a cage with the tail taped to a plastic dowel. The spinal cord on the level of the intumescentia lumbalis was taken from the experimental and control animals simultaneously on days 1, 3, 5, 7, 10, 14 and 30. Measurements: concentration and content of RNA in the spinal cord motoneurons.

IMMOBILIZATION METHOD: Cage (individual box, tail taped)

RESULTS: Within 1-30 days of hypokinetic exposure, RNA content was found to decrease on the 1st, 3rd and 5th day, and to return to the initial level by day 7. No changes in the RNA content were observed during the subsequent stages of the experiment. The volume of nerve cells declined on the 3rd and 5th day, whereas RNA concentration was reduced on days 1, 3, 5 and 30.

SOURCE: Tsitologiia 13(1): 83-87, 1971

AUTHOR(S): Gordiyenko, V.M., V.N. Slavnov, G.V. Valuyev, and T.I. Bogdanova

EXPERIMENT TITLE: Changes in the Functional State and Ultrastructure of the Zona Glomerulosa Cells of the Rat Adrenal Cortex Under Prolonged Immobilization Stress

SUBJECTS: Male Wistar rats, 45-50 days old

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) nonimmobilized controls; 2) rats immobilized by being fixed in a machine for 1, 2, 24, 48 and 72 hr. Fragments of the adrenals from 5 rats each of the 5 immobilization groups and the controls were prepared and examined under an electron microscope. Adrenal capsular sections were incubated with labeled pregnenolone and progesterone to determine the biosynthesis of aldosterone and its precursors by chromatography and scintillation counting. Measurements: radioactivity of corticosteroid derivatives; aldosterone, ACTH, and plasma renin content of the blood.

IMMOBILIZATION METHOD: Fixed in a machine

RESULTS: In the adrenocorticocytes of the zona glomerulosa, the cytoplasmic matrix revealed many liposomes exposed to vacuolization and myelin-like degeneration within 24 hr of immobilization, which progressed with the length of immobilization. Aldosterone, ACTH, and plasma renin content of the blood all increased in the 1st hr of immobilization. Aldosterone and ACTH levels dropped, and plasma renin continued to increase through the middle of the experiment. Aldosterone increased again by the end of the 72 hr experiment, but ACTH dropped below control levels. The specific radioactivity of DOC, corticosterone, and aldosterone in the capsular section of the adrenals decreased sharply in the 1st hr of immobilization. DOC and aldosterone levels continued to decrease, while the corticosterone level remained the same.

SOURCE: Problemy Endokrinologii 24(5): 91-96, 1978

AUTHOR(S): Gorgiladze, G.I. and G.S. Kazanskaya

EXPERIMENT TITLE: Effect of Restriction of Movement on Habituation by the Vestibular Apparatus

SUBJECTS: 16 Male and female rabbits (3-3.5 kg)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 8 controls; 2) 8 rabbits kept in restrictive cells for 30 days. Rabbits were then exposed to negative angular accelerations produced by a rotating platform installed in the axis of a laboratory centrifuge. The animals were subjected to single counterclockwise rotations. Later the rotatory tests were repeated clockwise 20 times at intervals of 5 min after which there was another counterclockwise rotation. An electro-nystagmogram was taken. Measurements: total number of nystagmus pulsations; duration of each reaction; the average frequency, amplitude, and duration; and the rates of the rapid and slow phases of nystagmus.

IMMOBILIZATION METHOD: Cell (small)

RESULTS: In the left-rotary and right-rotary pretests the nystagmus reaction of the experimental group was practically the same as the controls. With repetition of clockwise rotations, a difference between the 2 groups appeared at the 8th test; in the controls the reaction decreased progressively from rotation to rotation, whereas in the experimental animals it remained at practically the same level. No noticeable weakening of the reaction was displayed in any of the nystagmus indexes recorded for the experimental group.

SOURCE: Doklady Akademii Nauk SSSR 211(4): 1005-1008, 1973

AUTHOR(S): Gori,Z.

EXPERIMENT TITLE: Proliferations of the Sarcoplasmic Reticulum and the T System in Denervated Muscle Fibers

SUBJECTS: Albino rats (150-200 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: The left hind leg was denervated by sectioning the sciatic nerve; the contralateral muscles of the right leg served as the controls. Rats were killed at various times after denervation (2 to 45 days). 8-10 min before killing and fixation of the soleus muscle, 20-25 mg of horse-radish peroxidase tracer were injected into the aorta. Cross-sectional slices were prepared for electron microscope examination. Measurements: changes in the sarcotubular system of the soleus muscle.

IMMOBILIZATION METHOD: Denervation

RESULTS: Labyrinths of tubules appeared early after denervation and increased in number with the progression of atrophy. The peroxidase reaction product filled regularly the lumen of these structures as well as the central element of the triad. After long periods of denervation, lamellar structures composed of flat cisternae, or sacs, began to form. This occurred at around 20 to 30 days.

SOURCE: Virchows Archiv. B. Cell Pathology 11: 147-160, 1972

AUTHOR(S): Gorizontov, P.D., M.I. Fedotova, V.I. Gudim, and O.I. Belousova

EXPERIMENT TITLE: Comparison of Early Reactions of the Blood System in Rats to Immobilization, the Action of Hypoxia and the Administration of Erythropoietin

SUBJECTS: 295 Female Wistar rats (160-180 gm)

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: Three series of experiments: 1) 90 rats were immobilized on their backs for 6 hr; 2) 110 rats were maintained at low (0.5-0.3) barometric pressure for 9 hr; 3) 95 rats were given 10 units of domestic erythropoietin. Subjects were sacrificed at 6, 9, 12, 24 and 48 hr from stimulus. Measurements: cells from the thymus, spleen, marrow of the femur and bone marrow growths were calculated. In the peripheral blood, leucocyte number and formula were determined.

IMMOBILIZATION METHOD: Not stated

RESULTS: A unotypical reaction, characteristic of stress, was noted during the 1st hours; a reduction of the cell count in the lymphoid organs; a reduction of granulocytes and an increase of lymphoid cells in the bone marrow. This was followed by stimulation of myelo- and erythropoiesis determined by the specific action applied. Nonspecific blood reaction was apparently due to activation of the adaptation mechanisms under nervous-endocrine control.

SOURCE: Patologicheskaya Fiziologiya i Eksperimentalnaya Terapiya
No.3: 44-49, May-June 1977

AUTHOR(S): Gorizontova, M.P. and A.M. Chernukh

EXPERIMENT TITLE: Changes in Mast Cells and in Permeability of Mesenteric Microvessels Under the Effect of Immobilization and Electrostimulation

SUBJECTS: Male rats (200-280 gm)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Six groups: immobilization (fastened to a column for 24 hr) or electrical stimulation (2 amps for 3 sec, interval between impulses 90 sec). Electrical current was applied for 6 hr daily for 2 or 7 days. In each group, some of the animals received injections of esculamin 50 mg/kg 5 times over 3 days, the final time 1 hr before the experiment. Measurements: body, thymus and adrenal weight; mesenteric mast cell condition; microvascular permeability.

IMMOBILIZATION METHOD: Column

RESULTS: Immobilization for 24 hr and electrostimulation for 2 days caused a reduction in the number of mast cells in the mesentery and an increase in their degranulation, accompanied by an increase in the vascular permeability of the mesentery. Prophylactic use of esculamin decreased mast cell degranulation, which apparently prolonged the release of histamine and serotonin and normalized vascular permeability. After 2 days of electrostimulation, the body weight decreased 10%, thymus weights by 34% and adrenal weights increased by 35-40%.

SOURCE: Patologicheskaja Fiziologija i Eksperimentalnaja Terapija No.2: 73-76, 1974

AUTHOR(S): Gorizontova, M.P., O.V. Alekseev. and A.M. Chernukh

EXPERIMENT TITLE: Role of the Mast Cells in Disturbances of Vascular Permeability in Rats with Stress Due to Immobilization

SUBJECTS: 49 Noninbred male rats (200-300 gm)

AREA OF STUDY: Circulation; Pharmacology

OBJECTIVES: In title

PROTOCOL: Immobilization: 24 hr, in the supine position. Disturbances of vascular permeability were determined by the "labeled vessels" method, done 30 min before sacrifice. Dimebolin (1 mg/100 gm body wt, in 5 ml physiological saline, ip) and tipindole (2 µg/ml, physiological saline, ip in a volume of 5 ml) were injected twice - 30 min before immobilization and 30 min before ink labeling. The substance 48/80, a liberator of histamine and serotonin, was also injected. Heparin was injected ip (10 and 100 units per animal) in 5 ml physiological saline. Measurements: disturbances of permeability assessed from the number of labeled vessels examined in the mesentery and from the intensity of labeling.

IMMOBILIZATION METHOD: Not stated

RESULTS: Dimebolin and tipindole were found to have a protective action on vascular permeability. Dimebolin significantly reduced the number of labeled venules and the intensity of labeling; its protective effect was combined with a decrease in the number of mast cells (MC) in the mesentery and an increase in the number of degranulated mast cells. Tipindole, with weaker protective activity, had no significant effect on the number of MC or on their degranulation. After injection of substance 48/80 and in the absence of MC in the mesentery, immobilization caused more marked disturbances of vascular permeability; dimebolin under these conditions had no protective action. In the absence of MC in the mesentery with preliminary injection of substance 48-80, heparin simulated the protective effect of dimebolin. The protective action of heparin was manifested only if given in small doses.

SOURCE: Bulletin of Experimental Biology and Medicine 79(3): 241-244, 1975

AUTHOR(S): Gorizontova, M.P. and A.M. Chernukh

EXPERIMENT TITLE: Disturbance of Vascular Permeability and the Micro-circulation During Short-Term Immobilization Stress

SUBJECTS: 115 Male rats (200-250 gm)

AREA OF STUDY: Circulatory; Pharmacology

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls; 2) immobilization for 1 hr; 3) immobilization for 3 hr. The rats received an iv injection of 0.2 ml of purified ink. Some animals were given the following drugs: dimeboline and tipindole 30 min before immobilization; Tavegyl as a single dose 1 hr before immobilization. Measurements: microcirculation of the mesentery; histamine content of the mast cells.

IMMOBILIZATION METHOD: Not stated

RESULTS: Short-term (1 or 3 hr) immobilization stress caused disturbance of the microcirculation and permeability of the microvessels. There was an increase in vascular permeability for ink particles and in the mesenteric microvessels, formation of aggregates, appearance of plasmatic vessels, closure of arteriolar-venular shunts. After 1 hr immobilization, the number of mast cells increased; after 3 hr the number was reduced. Dimeboline reduced the extent and spread of lesions after 1 hr immobilization; Tavegyl prevented permeability disturbances after 1 hr immobilization and reduced the degree after 3 hr. Tipindole had a similar effect after 1 hr immobilization.

SOURCE: Bulletin of Experimental Biology and Medicine 81(6): 796-798, 1976

AUTHOR(S): Gorizontova, M.P., A.M. Chernukh, and Yu.V. Deshevoi

EXPERIMENT TITLE: Role of the Pituitary-Adrenal System in the Mechanisms
Regulating Vascular Permeability During Stress

SUBJECTS: 83 Wistar rats

AREA OF STUDY: Endocrine; Circulatory

OBJECTIVES: In title

PROTOCOL: Twelve groups: 1) hypophysectomy; 2) mock hypophysectomy; 3) hypophysectomy and immobilization for 1 hr; 4) mock hypophysectomy and immobilization for 1 hr; 5) hypophysectomy and immobilization for 3 hr; 6) mock hypophysectomy and immobilization for 3 hr; 7) adrenalectomy, 8) mock adrenalectomy; 9) adrenalectomy and immobilization for 1 hr; 10) mock adrenalectomy and immobilization for 1 hr; 11) adrenalectomy and immobilization for 3 hr; 12) mock adrenalectomy and immobilization for 3 hr. The rats were used in the experiments 14 days after hypophysectomy and 7 days after adrenalectomy. The rats were immobilized lying on their backs. Permeability of the microvessels in the mesentery was measured by vascular labeling; and state of mast cells by staining.

IMMOBILIZATION METHOD: Not stated

RESULTS: Hypophysectomy and adrenalectomy both disturbed the permeability of the mesenteric vessels. The disturbances of vascular permeability in hypophysectomized and adrenalectomized rats during immobilization were more marked than in animals undergoing the mock operations. Hypophysectomy and adrenalectomy led to degranulation of the mast cells in the earlier stages of immobilization.

SOURCE: Bulletin of Experimental Biology and Medicine 85(2): 129-131, 1978

AUTHOR(S): Gorski, J., B. Stankiewicz-Choroszucha, and S. Kozlowski

EXPERIMENT TITLE: Effect of Exercise and Adrenaline on Glycogen Metabolism in Skeletal Muscles of Hypokinetic Rats

SUBJECTS: Male Wistar rats (230-260 gm)

AREA OF STUDY: Muscular; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) hypokinesia for 28-30 days in cages 18 x 5 x 4.5 cm; 2) controls. The hypokinetic rats were then forced to run on a treadmill on a 10° incline at 1000 m/h for no longer than 15 min. They were sacrificed immediately or after 1-3 hr post-exercise recovery. Only water was allowed during recovery. The control group was sacrificed immediately after 15 min of exercise. Adrenaline (0.1 mg/kg) was administered sc in the lumbar region and skeletal muscle samples taken 1 hr later. Diet: rat pellet and water ad libitum. Measurements: samples of white muscle (superficial layer of the vastus lateralis), red muscle (deepest layer of the vastus lateralis), and intermediate muscle (soleus) were taken and assayed for glycogen.

IMMOBILIZATION METHOD: Cage (18 x 5 x 4.5 cm)

RESULTS: Exercise induced glycogen depletion in the muscles of hypokinetic rats was similar to that in the control rats. In the hypokinetic rats, adrenaline had no effect on the glycogen level in the white muscle and a mild but significantly reduced glycogen level in the red and intermediate muscles. No glycogen repletion occurred in the examined muscles during the 1st hr of the post-exercise recovery. In 3 hr of the recovery period there was pronounced glycogen repletion in the muscles but in each of them the glycogen level remained significantly lower than the respective pre-exercise level.

SOURCE: Acta Physiologica Polonica 29: 431-435, 1978

AUTHOR(S): Gottesfeld, Z., R. Kvetnansky, I.J. Kopin, and D.M. Jacobowitz

EXPERIMENT TITLE: Effects of Repeated Immobilization Stress on Glutamate Decarboxylase and Choline Acetyltransferase in Discrete Brain Regions

SUBJECTS: Male Sprague-Dawley rats (300-350 gm)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Two groups: 1) immobilization - intervals of 150 min each day for periods of 7 or 42 sequential days, subjects were maintained in a prone position by inserting their heads through steel wire loops fixed on a board and fastening their limbs to four metal strips with adhesive tape; 2) controls. Diet: food/water ad lib. Subjects were sacrificed by decapitation and brain removed. Measurements: glutamate decarboxylase (GAD) activity; choline acetyltransferase activity (ChAT).

IMMOBILIZATION METHOD: Steel wire loops, board, metal strips, adhesive tape

RESULTS: GAD activity increased by 24% in the globus pallidus (GP) and the ventromedial nucleus (VMN); these changes occurred only after long-term stress. A similar, albeit non-significant trend of GAD activity was noticed in the hypothalamic paraventricular nucleus. ChAT activity showed a decrease in the caudate nucleus (CN) after both 7 and 42 days, by 33% and 32%, respectively. No changes were detected in either GAD or ChAT activity in any of the limbic areas. Overall, changes were not uniform with respect to their magnitude, direction or sequence of appearance.

SOURCE: Brain Research 152: 374-378, 1978

AUTHOR(S): Graham, L.A.

EXPERIMENT TITLE: Effect of Phenoxybenzamine and Hydergine on Urinary Catechol Amines in Rats During Restraint

SUBJECTS: Male Sprague-Dawley rats (150 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Control (free) rats were kept in individual metabolism cages, without food and water, concurrently with restrained rats. Experimental rats were restrained in wire mesh, and suspended on rods above urine-collection bottles. Urine samples were collected and paired with samples of free rats. Period of restraint was 12 hr in the pre-test, and 16 hr in the repeated study. Rats restrained for 12 hr were injected with phenoxybenzamine 10 mg/kg or atropine sulphate 15 mg/kg. In the 16 hr group, free and restrained rats were given phenoxybenzamine 10 mg/kg or hydergine 1 mg/kg. Measurements: urinary excretion rates of adrenaline and noradrenaline.

IMMOBILIZATION METHOD: Wire mesh

RESULTS: Rats restrained for 12 and 16 hr excreted higher amounts of both adrenaline and noradrenaline than did free animals. Rats pre-treated with phenoxybenzamine excreted more adrenaline and noradrenaline than did controls; and these differences were pronounced during restraint. Hydergine did not alter resting excretion of adrenaline or noradrenaline but increased output of adrenaline in urine during restraint.

SOURCE: Acta Physiologica Scandinavica 68(1): 18-22, 1966

AUTHOR(S): Grant, R.

EXPERIMENT TITLE: Emotional Hypothermia in Rabbits

SUBJECTS: 36 Rabbits

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Pyrogen injection iv after 3 hr of restraint in wire mesh cloth cages. Environmental temperatures: 18°-30°C. Measurements: rectal and ear temperatures; respiration.

IMMOBILIZATION METHOD: Cage (wire mesh attached to wooden floor)

RESULTS: In 50 of 51 experiments, restraint at 18°-30°C activated heat loss mechanisms and some hypothermia. In 46 experiments (33 rabbits), hypothermia exceeded .5°C. At temperatures above 30°, heat loss mechanisms were strongly active in free rabbits and restraint caused little or no hypothermia. Oxygen consumption measurements under restraint did not significantly reduce heat production. One hr following pyrogen injection, persistent ear vasodilation and mild polypnoea interrupted the fever and rapidly lowered the rectal temperature until 1.25° of hypothermia developed; the temperature then stabilized.

SOURCE: American Journal of Physiology 160: 285-290, 1950

AUTHOR(S): Grechishkin, L.L. and K. Ritling

EXPERIMENT TITLE: The Effect of Immobilization and 3(β -Aminoethyl)-1,2,4-Triazol on the Calcium Content in Gastric Tissues of Guinea Pigs During the Formation of Experimental Ulcers

SUBJECTS: Guinea pigs (250-300 gm)

AREA OF STUDY: Digestive; Pharmacology

OBJECTIVES: In title

PROTOCOL: Three groups fasted for 12 hr: 1) 18 hr immobilization; 2) 2 injections of 3(β -aminoethyl)-1,2,4-triazol ip over 6 hr; 3) controls, saline injected. Measurements: volume and acidity of gastric contents number of ulcers in the mucous membrane and Ca^{+2} content of pyloric area and arterial blood by atomic absorption.

IMMOBILIZATION METHOD: Metal screen

RESULTS: The concentration of calcium in the gastric tissue was found to be 398 γ/gm in the controls, 317 γ/gm (79%) in the immobilized animals and 287 γ/gm (71%) in those animals receiving the histamine analog. There were similar shifts in the blood plasma: immobilized animals 53.4 γ/ml (65%); controls 81.7 γ/ml ; histamine treated 75.0 γ/ml (91%).

SOURCE: Farmakologiya i Toksikologiya 39(1): 86-89, 1976

AUTHOR(S): Grek, O.R.

EXPERIMENT TITLE: Effect of Hypoxia and Hyperthermia on the Processes of Lipid Peroxidation in the Rat Liver Against a Background of the Action of Gutimine and Unsaturated Amines

SUBJECTS: Wild white rats (170-270 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Three series: I - 5 groups of 9 rats kept hypodynamic in a ventilated thermochamber at 32°C: 1) controls; 2) hypodynamia without treatment; 3) hypodynamia, administered tocopherol; 4) hypodynamia, administered gutamine; 5) hypodynamia, administered acetylene amine (1,4-bis-(3-morpholinopropinyl)-benzol). Series II - Rats were maintained for 3 hr at a negative pressure (258 mHg) simulating 8000 m altitude. Series III - Rats were maintained under hypoxic conditions for 1 hr in an oxygen atmosphere. Experimental tissues were incubated for 60 min at 37°C at pH 4.7, under spectrum lamp irradiation for 5 min. Measurements: lipid peroxidation of liver tissue.

IMMOBILIZATION METHOD: Not stated

RESULTS: Exposure to extreme factors (hypoxia, hypoxia + hyperoxia, hypodynamia + hyperthermia) resulted in an accumulation of malonic dialdehyde with a simultaneous decrease of antiradical activity of the liver tissue. The preliminary administration of acetylene amines, tocopherol antioxidants and gutimine antihypoxant averted activation of the lipid peroxidation processes. This inhibition of peroxidation was attended by stabilization of lyzosomal and mitochondrial membranes. Unsaturated amines prevented destruction of the organelles membranes provoked by UV irradiation and incubation at 37°C.

SOURCE: Farmakologiya i Toksikologiya 41(1): 101-104, 1978

AUTHOR(S): Grinberg, L.N.

EXPERIMENT TITLE: Change in Respiration of Rat Liver Mitochondria During Prolonged Hypokinesia

SUBJECTS: 68 Mongrel rats (160-190 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinesia in individual cells (20 x 5 x 7 cm) for 10, 20, 30 or 60 days. Measurements: respiration and phosphorylation in liver mitochondria.

IMMOBILIZATION METHOD: Cells (20 x 5 x 7 cm)

RESULTS: There was a change in the rate of respiration of mitochondria only after 30 days of hypokinesia. With 30-day-long hypokinesia, the weight of mitochondrial respiration in the 4th state exceeded by more than three times this value in the control with the use of succinate. For the NAD-dependent substrate (α -ketoglutarate), respiration of mitochondria of hypokinetic animals was characterized by an increase in the rate of respiration in the 4th state and a decreased rate in the 3rd state, in comparison with the control. A decrease in the magnitude of respiratory control was particularly pronounced at the 30th day of hypokinesia while, by the 60th day, there was a tendency toward an increase in its value.

SOURCE: Voprosy Meditsinskoi Khimii 16: 387-390, 1970

AUTHOR(S): Gross, A.L., K.T. Roberson, L.H. Krough, Jr., and J.W. Miesse

EXPERIMENT TITLE: A Study of Calcium, Phosphorus, and Nitrogen Mobilization Resulting From Conditions of Inactivity in Macaca irus Monkeys

SUBJECTS: Adult male Macaca irus monkeys

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Three phases of experiment - I) 28 days, 4 groups of 3 animals each: 1) control; 2) denervation (severing femoral and sciatic nerves); 3) tranquilization (3 mg/kilo Tranimul im twice daily); and 4) plaster cast (sitting position). Phase II) 28 days, 2 groups: 1) plaster cast monkeys from phase I remained inactivated, 6 additional monkeys were inactivated in casts; 2) 3 controls. Phase III) 4 days, 3 groups of 4 animals each: 1) control; 2) plaster cast (sitting position); 3) plaster cast (horizontal position). Diet: Purina monkey chow. Measurements: food intake; calcium, phosphorus, and nitrogen analyzed separately in urine and feces daily. For phase III, the urine and fecal samples were pooled for the monkeys cased in the horizontal position.

IMMOBILIZATION METHOD: Denervation; Plaster cast: Drug

RESULTS: No significant changes occurred in either calcium or phosphorus balance in the inactivated monkeys. Urinary phosphorus excretion was increased during periods of inactivation, but there was no overall negative balance. Almost immediately after inactivation, the animals in the plaster casts and surgically denervated animals went into what appeared to be a negative nitrogen balance. The increase in nitrogen excretion was seen only in the urine.

SOURCE: Southwest Research Institute, San Antonio, Texas, 1966, 42 pp.

AUTHOR(S): Gross, J.H., K.M. Knigge, and M.N. Sheridan

EXPERIMENT TITLE: Fine Structure of Neurons of the Arcuate Nucleus and Median Eminence of the Hypothalamus of the Golden Hamster Following Immobilization

SUBJECTS: Male golden hamster, Chick-line strain (100-125 gm)

AREA OF STUDY: Endocrine; Nervous

OBJECTIVES: In title

PROTOCOL: Two groups: 1) immobilization - hamsters held under a wire screen continuously for periods of 5, 15, 30 and 60 min; 2) controls. Diet: food and water ad libitum for at least 7 days prior to experiment. Subjects were sacrificed by decapitation. Measurements: morphological analysis of neurons of the arcuate nucleus and median eminence of the hypothalamus; plasma cortisol activity.

IMMOBILIZATION METHOD: Wire screen

RESULTS: Arcuate neurons of the immobilized adult male hamster displayed morphological indications of heightened activity; the number of lysosomes and dense core vesicles was increased. A markedly greater number of dense core vesicles was present in axon terminals of the contact zone of the mid-central median eminence and the ventral proximal stalk. Tancytes of the median eminence exhibited an augmented number of electron dense bodies in both perikarya and end processes. There was an acute increase in plasma cortisol concentration.

SOURCE: Cell and Tissue Research 168: 385-397, 1976

AUTHOR(S): Groza, P., S. Cananau, D. Ungureanu, M. Dobre, A. Petrescu, and C.T. Dragomir

EXPERIMENT TITLE: Na^+ and K^+ Dependent ATP-ase and Structural Modifications in Hypokinetic Rats

SUBJECTS: 40 Male rats (180-200 gm)

AREA OF STUDY: Muscular; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups of 20 each: 1) 15 and 30 days of hypokinesia in cages; 2) controls. Following restraint, rats were decapitated and the right soleus muscle and the left ventricular myocardium were removed. Measurements: membrane ionic transfer; skeletal and cardiac muscle.

IMMOBILIZATION METHOD: Cage

RESULTS: After 30 days of hypokinesia there was a marked decrease in Na^+ and K^+ dependent adenosine triphosphate (ATP-ase) in the skeletal muscle. Enzymatic content of the investigated tissues in hypokinetic rats did not change. In the left cardiac ventricular muscle, Na^+ and K^+ dependent ATP-ase decreased after 15 days and especially so after 30 days hypokinesia. These changes were produced by the hypofunctional state of both muscles, which also produced structural alterations. In the skeletal and cardiac muscles, electron microscopy showed fibrillar atrophy and mitochondrial alterations. These changes, which were more accentuated in the cardiac muscles, showed dissociation of the intercalar disc.

SOURCE: Physiologie 14(4): 219-223, 1977

AUTHOR(S): Groza, P., A. Bordeianu, S. Cananau, C. Dragomir, and D. Ungureanu

EXPERIMENT TITLE: The Effect of Hypokinesia on Some Organs of the Digestive Tract (Submaxillary Glands, Stomach, Small Intestine and Pancreas)

SUBJECTS: 40 Male rats (180-200 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Three groups: 1) hypokinesia for 15 days (10 rats); 2) hypokinesia for 30 days (10 rats); 3) controls (20 rats). Food and temperature conditions were similar for all groups. The animals were killed by decapitation. Fragments were collected from the submaxillary glands, from the stomach (fundus and pyloric antrum), pancreas and intestine for histochemical analysis and electron-microscopic examination.

IMMOBILIZATION METHOD: Cage

RESULTS: A decreased mucopolysaccharide content of submaxillary, gastric and duodenal glands was found. A slight diminution of ribonucleic acid and proteins was noted in the serous cells of the submaxillary gland after 15 days; a return towards normal was registered after 30 days of hypokinesia. Examination of the fundus glands revealed a diminution of cytoplasmatic density in the parietal cells after 15 and 30 days. There was an increase in the number of intracellular canaliculi and a large number of mitochondria with a great number of cristae after 30 days. There was a marked accumulation of eosinophils in the deep layers of gastric glands. The goblet intestinal cells appeared vacuolated. The beta cells of the endocrine pancreas was found in a hyperactive state after 15 days hypokinesia followed by a return to almost normal on day 30.

SOURCE: Physiologie 15(1): 3-9, 1978

AUTHOR(S): Groza, P., A. Bordeianu, S. Cananau, D. Lungu, C.T.
Dragomir and D. Ungureanu

EXPERIMENT TITLE: The Effect of 60-Day Hypokinesia on Submaxillary,
Stomach, Small Intestine Glands and on Gastric
Secretion

SUBJECTS: Rats

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two series: I - groups: 1) controls; 2) experimental rats maintained in cages for 60 days. II - groups: 1) controls; 2) groups of 8 rats maintained for 1, 2, 7, 15, 30 and 50-day hypokinesia. Measurements: for series 1 - mucous secretion of submaxillary glands, stomach and intestine, the endocrine gastrin secreting G cells of the antrum, and the secretion of leucine-amino-peptidase, acid phosphatase and glucose-6-phosphatase; for series 2 - free and total acid output, pepsin output.

IMMOBILIZATION METHOD: Cage

RESULTS: After 60-day hypokinesia, the mucopolysaccharide content of submaxillary glands, gastric glands and epithelial mucous secretion and the mucous content of the goblet intestinal cells, which were diminished after 15 days and less diminished after 30 days, tended to normalize. After 60 day-hypokinesia normalization of intestinal enzyme secretion was found. The aspect of gastrin secreting Grimelius positive G cells was also normalized. In the gastric secretion of rats, the free and total acid and pepsin output was increased after 1, 7, 15 and 30-day hypokinesia with maximal value found after 7 days. After 50 days the acid and pepsin output equaled normal control values.

SOURCE: Physiologie 15(4): 249-251, 1978

AUTHOR(S): Guerrin, F., A. Demaille, P. Merveille, and C. Bel

EXPERIMENT TITLE: Effects of the Enzymatic Inhibitor of Kunitz on the Gastric Lesions From Reserpine, From Phenylbutazone, From Pyloric Ligation and by Restraint in the Rat

SUBJECTS: Male and female Wistar rats

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Eight groups: 1) reserpine treated controls; 2) reserpine treated, given kunitz inhibitor; 3) phenylbutazone treated controls; 4) phenylbutazone treated, given kunitz inhibitor; 5) pyloric ligation, controls; 6) pyloric ligation, treated with kunitz inhibitor; 7) restraint control; 8) restraint, treated with kunitz inhibitor. Kunitz enzymatic inhibitor was administered on 3 consecutive days (25,000-50,000 U/kg). The last injection was $\frac{1}{2}$ hr following ulcerogenic action, or immediately before restraint. Rats were killed, and stomachs studied by systematic serial sections. Measurements: average number of lesions per rat.

IMMOBILIZATION METHOD: Not stated

RESULTS: Kunitz inhibitor either prevented or lessened the incidence of ulcers after reserpine or phenylbutazone administration. It exerted no effect on Shay ulcers or stress ulcers from restraint.

SOURCE: Comptes Rendus des Seances de la Societe de Biologie et de ses Filiales 159(5): 1172-1174, 1965

AUTHOR(S): Guth, L.

EXPERIMENT TITLE: Effect of Immobilization on Sole-Plate and Background Cholinesterase of Rat Skeletal Muscle

SUBJECTS: 14 Osborne-Mendel female rats (200-260 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Disuse atrophy of the rat's soleus muscle was produced by internal fixation of the knee and ankle joints and denervation atrophy by transection of the sciatic nerve. Approximately half of the operations were done on the left side and half on the right side. All rats were killed 4 days postoperatively. Measurements: body weight; protein content, sole-plate and cholinesterase activity (ChE) of the skeletal muscles.

IMMOBILIZATION METHOD: Internal fixation; Denervation

RESULTS: The average body weight of the animals subjected to the immobilization alone (234 ± 12 gm) was comparable to that of the animals subjected to immobilization plus denervation (234 ± 17 gm). The immobilized muscles lost 19.9% of their protein content whereas the immobilized and denervated muscles lost 31.7%. The percentage decrease in background ChE was very similar to the protein loss, being 22.4% after immobilization and 35.6% after immobilization plus denervation; consequently the specific background activity (background ChE per microgram of protein) showed no significant change from normal after either of the operative procedures. Immobilization alone produced a relatively small (not significant) decrease in sole-plate ChE (8.7%) where immobilization plus denervation produced a 53.4% decrease.

SOURCE: Experimental Neurology 24: 508-513, 1969

AUTHOR(S): Guth, P.H. and R. Mendick

EXPERIMENT TITLE: The Effect of Chronic Restraint Stress on Gastric
Ulceration in the Rat

SUBJECTS: 35 Male albino rats (45-65 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Six groups: one group of 10 and five groups of 5 each. Rats were deprived of food for 18 hr, after which they were lightly anesthetized and immobilized by folding and securing galvanized screen about their bodies. After recovery from anesthesia, the rats were kept in restraint for 4 hr. The group of 10 rats was then killed by ether overdosage. The remaining groups were allowed food ad libitum for 2 hr, and then the period of fasting and restraint repeated; they were killed at weekly intervals up to 5 wk, during which time they were subjected to daily restraint. The stomachs of the animals were studied. Measurements: incidence of ulcerations; rat mortality; observed struggle under restraint; fecal excretion during restraint.

IMMOBILIZATION METHOD: Galvanized window screen

RESULTS: No lesions of the small or large bowels but only superficial lesions of the glandular portion of the stomach were produced. The single restraint groups (10 rats) showed lesions in 50% compared to 10% of the control group. Repeated restraint groups showed a much lower incidence of ulcerations. Repeated restraint was associated with reduced struggling and decreased fecal excretion under restraint. Mortality increased with the duration of stress, but was not associated with lesions. Dying rats all lost or failed to gain weight; surviving rats gained 6-11 gm/wk.

SOURCE: Gastroenterology 46(3): 285-286, 1964

AUTHOR(S): Guth, P.H. and P. Hall

EXPERIMENT TITLE: Microcirculatory and Mast Cell Changes in Restraint-Induced Gastric Ulcer

SUBJECTS: 60 Albino rats (100-350 gm)

AREA OF STUDY: Digestive; Circulatory

OBJECTIVES: In title

PROTOCOL: Six groups of 10 rats each. Rats were deprived of food for 12 to 48 hr, after which they were lightly anesthetized and immobilized by folding and securing galvanized screen about their bodies. After recovery from anesthesia, the animals were kept in restraint for 1/2, 2, 4, 6, 18 and 24 hr. The rats were then lightly reanesthetized with ether, the stomachs removed, and animals sacrificed by bilateral thoracotomy. Measurements: incidence of ulcers; relative blood content of gastric mucosa; mast cell count.

IMMOBILIZATION METHOD: Galvanized window screen

RESULTS: Restraint produced statistically significant blood accumulation in microvessels immediately beneath the surface epithelium, but not deeper in the mucosa; control rats showed an uniform blood distribution throughout the mucosa. Circulatory changes occurred prior to the development of ulceration in the first hour of restraint. No further increase in mucosal blood accumulation occurred with more prolonged restraint. Ulceration involved the hyperemic region of mucosa adjacent to the lumen. Restraint was associated with a marked decrease in the number of mast cells in mucosa just below the epithelium, this decrease occurred during the first half hour of restraint.

SOURCE: Gastroenterology 50(4): 562-570, 1966

AUTHOR(S): Guth, P.H. and X. Kozbur

EXPERIMENT TITLE: Pathogenesis of Gastric Microcirculatory and Mast Cell Changes in Restraint Stress

SUBJECTS: Albino rats

AREA OF STUDY: Digestive; Circulatory

OBJECTIVES: In title

PROTOCOL: Restraint: 4 hr. The rats were lightly anesthetized and then immobilized by folding and securing galvanized screen about their bodies. 3 groups: 1) vagotomized-restraint vs unrestrained; 2) adrenalectomized-restrained vs unrestrained; 3) drug injected-saline (control), urecholine, hydrocortisone and epinephrine. Measurements on gastric mucosa: mast cell counts were performed on toluidine blue-stained tissue sections. Relative blood content was determined by densitometric measurements on thick cleared sections of hemoglobin-stained tissue.

IMMOBILIZATION METHOD: Galvanized screen

RESULTS: Following vagotomy, 4 hr of restraint resulted in a statistically significant decrease in mucosal mast cells, no change in mucosal blood content, and no gastric ulceration. Following adrenalectomy, restraint resulted in a statistically significant accumulation of blood in mucosal microvessels, no change in mucosal mast cells and an increased incidence of gastric ulcers. The intraperitoneal injection of urecholine and epinephrine resulted in a statistically significant increase in mucosal blood content but no change in mast cells, while intraperitoneal injection of hydrocortisone resulted in a statistically significant decrease in mucosal mast cells but no change in blood content. No causal relationship was found between gastric mucosal mast cell degranulation and gastric mucosal vascular engorgement.

SOURCE: American Journal of Digestive Diseases 13(6): 530-535, 1968

AUTHOR(S): Guth, P.H. and X. Kozbur

EXPERIMENT TITLE: Microcirculatory and Mast Cell Changes in Restraint Stress: Role of Gastric Acid

SUBJECTS: Albino Wistar rats (aver. 120 gm)

AREA OF STUDY: Digestive; Circulatory

OBJECTIVES: In title

PROTOCOL: Restraint: 1/2 or 4 hr. Rats were deprived of food for 24 hr, but were allowed free access to water. After the fast, they were lightly anesthetized with ether and a catheter was inserted per os into the stomach. Three milliliters of a 15% sodium bicarbonate solution were instilled into the rat's stomach and the catheter removed. Some of the rats were then restrained by folding and securing galvanized screen about their bodies. The rats were then lightly reanesthetized with ether, the stomachs removed, and the animals sacrificed by bilateral thoractomy. Measurements: gastric pH; mast cell count; incidence of ulcers.

IMMOBILIZATION METHOD: Galvanized screen

RESULTS: Following 1/2 hr of restraint, there was a statistically significant accumulation of blood ($p < 0.01$) and decrease in mast cells ($p < 0.01$), in spite of persistently high intraluminal gastric pH (> 7.7). Following 4 hr of restraint, both changes were even more highly significant, ($p < 0.001$), even though the intraluminal gastric pH remained high (> 3.4). No gastric mucosal areas of significantly different pH from that of the gastric content were found in any animal, as determined by rubbing pH paper. No ulcers occurred in the rats restrained for 1/2 hr, but ulcers occurred in 3 of 16 rats (18.7%) subjected to 4 hr of restraint. In these 3 animals, the gastric pH was 3.4, 3.5 and 7.1 (the last rat's stomach was filled with blood).

SOURCE: American Journal of Digestive Diseases 14(2): 113-117, 1969

AUTHOR(S): Guth, P.H.

EXPERIMENT TITLE: Gastric Blood Flow in Restraint Stress

SUBJECTS: Male albino Wistar rats (160-210 gm)

AREA OF STUDY: Digestive; Circulatory

OBJECTIVES: In title

PROTOCOL: Rats were fasted for 48 hr following which they were lightly anesthetized with ether and immobilized by folding and securing galvanized screen about their bodies. Following recovery from anesthesia, rats were restrained for 0, 1/2, 4 or 24 hr. For flow fractions, 200 $\mu\text{Ci/kg}$ $^{86}\text{RbCl}$ was injected over a 10-sec period into the inferior vena cava. For cardiac output, 11 μCi $^{86}\text{RbCl}$ was injected into the jugular vein. Diet: water ad libitum. Measurements: cardiac output; gastric flow fractions; gastric blood flow.

IMMOBILIZATION METHOD: Galvanized screen

RESULTS: There was no correlation between gastric mucosal blood flow changes and the natural development of restraint erosions.

SOURCE: Digestive Diseases and Sciences 17(9): 807-813, 1972

AUTHOR(S): Gvishiani, G.S. and N.G. Kobakhidze

EXPERIMENT TITLE: Dynamics of Change of Lipid and Monoamine Metabolisms and the Blood Coagulation System During Experimental Atherosclerosis Caused by Restriction of Movement

SUBJECTS: Chinchilla rabbits

AREA OF STUDY: Metabolism; Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) immobilized for 4 mo alternating periods of 10 days restriction followed by 10 days of unrestricted motion (6 rabbits); 2) controls (10 rabbits). Measurements: blood samples analyzed monthly for general cholesterol, lecithin, β -lipoproteins, general coagulation, prothrombin index, catecholamines. The above indices were measured in the myocardium, liver, thalamus and brainstem reticular formation after decapitation.

IMMOBILIZATION METHOD: Cage

RESULTS: Periodic motion restriction caused an increase in blood β -lipoproteins in the animals at the beginning of the experiment. An increase in general cholesterol and a decrease in the lecithin-cholesterol index were established at the end of the experiment. Myocardial β -lipoprotein and brainstem reticular formation general cholesterol contents were elevated; catecholamine content was increased at the end of the experiment. Initially, free adrenaline increased, while later it decreased and blood norepinephrine increased.

SOURCE: Soobshcheniia Akademii Nauk Gruzinskoi SSR 60(2): 445-447, 1970

AUTHOR(S): Gvishiani, G.S., N.G. Kobakhidze, M.G. Mchedlishvili, and T.I. Dekanosidze

EXPERIMENT TITLE: Atherosclerotic Changes of Vessels Caused By Restriction of Movement

SUBJECTS: 16 Rabbits

AREA OF STUDY: Circulatory; Blood

OBJECTIVES: In title

PROTOCOL: Rabbits were placed in narrow cages for 10, 20 and 30 days. Samples of blood were taken before movement restriction and at the end of the experiment; the animals were then sacrificed and their aortas were morphologically studied. Measurements: cholesterol, β -lipoproteins, catecholamines; blood coagulation system indices; EKG.

IMMOBILIZATION METHOD: Cage (narrow)

RESULTS: Restriction of movement had a definite effect on blood lipoproteins; 10 days following the beginning of restricted movement the quantity of β -lipoproteins increased. The general cholesterol level increased following 20-30 days. Catecholamine content increased, free adrenaline increased in the first few days of the experiment, and noradrenaline increased after 20-30 days. Recalcification time decreased, prothrombin index increased. Shifts in EKG obtained: deviation in the S-T interval from the isoelectric line and deformations in the T wave were most striking. Restriction of movement caused atherosclerotic changes in the walls of the aorta.

SOURCE: Soobshcheniia Akademii Nauk Gruzinskoi SSR 59(3): 701-704, 1970

AUTHOR(S): Hadjioloff, A.I., T.M. Shivatcheva, L.P. Cherescharov,
L.V. Lazarova, and S.I. Toshkova

EXPERIMENT TITLE: Cell-Tissue Changes in Lymph Nodes of Loaded and
Immobilized Rats

SUBJECTS: 30 Female Wistar rats (85±5 days old)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Restraint: 326 days. 3 groups of 10 rats each: 1) functional
loading (daily running 6 days/wk at 3 speeds: 550, 703 and 940 m/hr);
2) restrained in cells; and 3) controls. All rats were killed following
testing; group 1 after 275 trainings. Measurements: lymph nodes; cells.

IMMOBILIZATION METHOD: Cell

RESULTS: Quantitatively there were certain fluctuations in the number of
lymphocytes, plasmocytes, blasts, and reticular cells within the normal
range. Axillary and mediastinal lymph nodes were polarly located on the
cortex and medulla. The cortex was larger than the medulla in the controls.
Typical histological and cytological changes were seen in both node types
of the loaded rats. Lymph nodes of the restrained rats showed analogous
histological and cytological results. There was a reduction of the cortex
and an increase of the medulla, a thickening of the latter's cords, and a
large number of plasmocytes were seen. Quantitatively there were smaller
changes in the lymphocytes and reticular cells and an increase of the
plasmocytes.

SOURCE: Comptes Rendus de l'Academie Bulgare des Sciences 27(8):
1161-1162, 1974.

AUTHOR(S): Hadjiolova, I.

EXPERIMENT TITLE: Changes of Plasma and Adrenal Corticosteroids in Rats During Hypokinesia and Other Stresses

SUBJECTS: 270 Male Wistar rats, (190-210 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Stresses: hypokinesia (narrow cage), heat (65°C water immersion), noise (500-1900 Hz at 80-90 dB). Eight groups: 1) hypokinesia - 60 animals, 1, 3, 7, 14, 30 and 60 days; 2) controls - 30 animals; 3) heat stress subsequent to 14, 30, or 60 days of hypokinesia, 10 animals; 4) heat stress - 20 animals; 5) 30-day hypokinesia followed by a single 14 hr noise exposure, 10 animals; 6) single noise exposure - 3, 6, or 14 hr, 24 animals; 7) 14 hr noise exposure during 30 day hypokinesia - 40 animals, 10 killed 24 hr after end of the last noise exposure, others killed at 3, 6 or 14 hr after last exposure; 8) chronic noise - 40 animals. Diet: Altromin as food and water ad lib. Measurements: plasma and adrenal corticosteroids, body weight, adrenal weight.

IMMOBILIZATION METHOD: Cage (narrow)

RESULTS: A moderate but significant increase in the levels of both plasma and adrenal corticosterone was observed after 24 hr of hypokinesia. In a subsequent period of 60 days the corticosterone levels did not differ significantly from the levels found in the control animals. Heat stress produced a strong increase in the plasma and adrenal cortical steroids; there was a lower increase of adrenal corticosteroid after 30 days of hypokinesia, and after 60-day hypokinesia there was a significantly less rise in plasma and adrenal cortical corticosteroids. Single noise exposure (14 hr) caused a significant increase in the plasma corticosteroid levels after a 30-day hypokinesia. As the animals were exposed to extended stress, no distinct increase of the adrenal corticosteroid values was found, in contrast to the increased values in the plasma. There was a tendency toward decrease in corticosteroid content in the adrenals of chronically noise-exposed rats. A significant decrease in the rise of the plasma corticosteroid level in groups after 3, 6, or 14 hr of noise exposure, with or without hypokinetic pretreatment, was observed. Weight changes: the total increase in body weight during the experimental period was 13.6% for the rats under hypokinesia and 45% for the controls. The weights of the adrenals decreased in comparison to the control weights as duration increased.

SOURCE: Internationales Archiv fuer Arbeitsmedizin 33: 59-70, 1974

AUTHOR(S): Hadjiolova, I., D. Markov, and E. Nakasheva

EXPERIMENT TITLE: Studies on the Functional Activity of the Adrenal Cortex in Rats Under Prolonged Hypokinesia

SUBJECTS: 110 Male albino rats (200-220 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Seven groups: 1) 15 rats studied immediately after 60-day hypokinesia in cells; 2) 15 intact rats killed at the same time as group 1 rats; 3) 10 rats after 60 days hypokinesia were subjected to thermal stress and killed 90 min poststress; 4) 10 controls subjected to thermal stress only; 5) 8 experimental and 8 control rats killed 1 hr after sc injection of 1 mg/100 gm body weight of histamine dehydrochloride; 6) 8 experimental and 8 control rats killed 1 hr after ip injection of 20 μ g/100 gm body weight adrenaline; and 7) 12 experimental and 12 control rats killed 1 hr after sc injection of 3 IU ACTH/100 gm body weight. Measurements: adrenal weight; lipid distribution of the adrenal cortex; ultrastructural study of zona fasciculata cells; glucose 6-phosphate dehydrogenase activity; adrenocortical tissue and plasma corticosterone level.

IMMOBILIZATION METHOD: Cell (8 x 5.5 x 8 cm; length adjustable)

RESULTS: Hypokinesia changed the mitochondria of zona fasciculata cells: 1) the mitochondria matrix was brighter, 2) the cristae were reduced, and 3) in some mitochondria only single cristae could be seen. Hypokinesia also induced a less marked increase of adrenal and plasma levels of corticosterone after heat stress and histamine administration, namely, a weaker reaction of the adrenal cortex to additional stress.

SOURCE: Agressologie 16(3): 187-191, 1975

AUTHOR(S): Hakkinen, I., K. Hartiala, and H. Lang

EXPERIMENT TITLE: The Effect of Restraint on the Content of Acid Polysaccharides of Glandular Gastric Wall in Rat

SUBJECTS: 120 Female Wistar rats (180-200 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Both the control and restrained rats were starved for 12 hr prior to the experiment. 12 groups (10 rats each) were subjected to various periods of restraint from 5-48 hr. The restraint began in the morning for the 5, 6, 8, 24, 28 and 48 hr groups, in the afternoon for the 12, 14, 16, 18 and 20 hr groups. During the restraint period no food or drink was given to the rats. After killing, the animals stomach was opened and the ulcers and other visible lesions noted. Total polysaccharides in the glandular stomach were determined, and fractionation of acid polysaccharides was performed in a control group and in the 24 hr restraint group.

IMMOBILIZATION METHOD: Not stated

RESULTS: Most of the ulcers found were in the 24-hr group. After a restraint period of 5 to 20 hr no ulcers were observed, only smaller lesions. These were more abundant and defined at the beginning of the restraint (i.e. 5-8 hr). There was some tendency for the acid polysaccharides to be increased after a short restraint of 8 hr. After restraint of 14 to 20 hr there was no significant difference from the control group. The 24-hr group showed a large increase. The values for the 28 and 48 hr groups were lower than in the control group also, although not so low as the 24-hr group. Fractionation of polysaccharides from the 24-hr group showed that the fractions believed to contain connective tissue polysaccharides and one of the fractions containing epithelial mucopolysaccharides fell significantly. Only one rat in each of the 24- and 28-hr groups died.

SOURCE: Acta Physiologica Scandinavica 66: 333-336, 1966

AUTHOR(S): Hall, M.C.

EXPERIMENT TITLE: Cartilage Changes After Experimental Immobilization of the Knee Joint of the Young Rat

SUBJECTS: 40 Young male rats, Sprague-Dawley strain (mean weight 95 gm)

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Two groups: 1) immobilization - both knees immobilized in position held mid-way between full flexion and full extension, operative insertion of sterile wires, groups of 3-4 animals were sacrificed at intervals of 27, 31, 42, 53, 90 and 123 days after operation; 2) controls. Measurements: histological study of the knees.

IMMOBILIZATION METHOD: Internal fixation with wire

RESULTS: 27 days after the operation, both the femoral and tibial articular cartilage were thickened at the point of contact through which an increased amount of weight per unit area was being transmitted. During this interval the point of contact changed from the minimum area of apposition of the two curved surfaces to a flattened area on both joint surfaces or to a shallow reciprocal concave-convex relationship. At 53 days, cellular activity in the cartilage was diminishing, but the abnormal thickness at the area of contact remained. At 123 days, thickening of both femoral and tibial cartilage remained at the area of contact. The cartilage showed a normal histological appearance with respect to the layers and size of the cells.

SOURCE: Journal of Bone and Joint Surgery 45-A(1): 36-44, 1963

AUTHOR(S): Hanninen, O. and K. Hartiala

EXPERIMENT TITLE: The Induction of Liver Tyrosine 2-Oxoglutarate Transaminase in Rats by Immobilization

SUBJECTS: Young female Wistar rats (90-100 gm)

AREA OF STUDY: Digestive; Metabolism and Energy Exchange

OBJECTIVES: Determine whether change in liver metabolism due to activation of adrenals coincides with appearance of gastric lesions during immobilization

PROTOCOL: Restraint: up to 56 hr. Adrenalectomized rats were operated on 7 days before use; they were maintained by adding sodium chloride (1%) to the drinking water. Rats were immobilized by feet fixation with plaster in a net cylinder. Actinomycin D was injected sc 30 min before immobilization. The glucocorticoid effect on the enzyme activity was controlled by injecting Cortone Acetate im 3 hr before the analysis. The rats were stunned and bled immediately after liberation, and the most ventral lobe of the liver was transferred to ice. Diet: fed ad libitum until start of the experiment. Measurements: liver tyrosine 2-oxoglutarate transaminase; incidence of gastric lesions (micro- and macroscopic).

IMMOBILIZATION METHOD: Plaster, net cylinder

RESULTS: A linear increase in liver tyrosine 2-oxoglutarate transaminase activity reached a 4-fold level within 12 hr; a decrease followed. No macroscopic gastric lesions were observed in 26 hr; many cases of macroscopic lesions were found in rats immobilized for 40 hr or more. The enzyme activity in the liver of rats with macroscopic gastric lesions was double or more than double the activity in immobilized rats with no lesions or in nonimmobilized controls. Adrenalectomized rats showed no increase in enzyme activity during immobilization. The increase in liver tyrosine 2-oxoglutarate transaminase seemed to precede the appearance of gastric lesions.

SOURCE: Acta Endocrinologica 54: 85-90, 1967

AUTHOR(S): Hano, J., J. Bugajski, L. Danek, and C. Wantuch

EXPERIMENT TITLE: The Effect of Neuroleptics on the Development of Gastric Ulcers in Rats Exposed to Restraint-Cold Stress

SUBJECTS: 550 Wistar rats of both sexes (180-255 gm)

AREA OF STUDY: Digestive; Pharmacology

OBJECTIVES: In title

PROTOCOL: Two groups: 1) immobilization and cold restraint - periods of 1, 2, 3 or 4 hr, animals immobilized in special cages placed in a cold chamber at 6°C; 2) controls. For 18 hr before the experiment animals received no food but had free access to water. Chlorpromazine (CPZ), thioridazine (TRZ), spiroperidol (SPI), and fluphenazine (FLU) were administered ip to 3 hr subjects before the start of stress. Measurements: glucose, free fatty acids (FFA), choline esterase (CLE), K and Ca concentrations, incidence, average number and diameter of stomach lesions.

IMMOBILIZATION METHOD: Cage

RESULTS: Minor lesions of the gastric mucosa appeared in the 1st hr, and were intensified 2 to 5 times in the 2nd and 3rd hrs of stress. During stress, the volume of secretion and the output of HCl decreased although the concentration rose slightly. CPZ, TRZ, SPI, and FLU inhibited to various degrees ulcer formation during stress. SPI reduced stress-induced mucosal damages in 94%, but FLU, even in doses 100 times smaller than those of the other drugs counteracted ulcer formation. CPZ, TRZ, and SPI in preventive doses increased proportionally the blood glucose levels of both control and stressed rats. FLU in effective doses produced no hyperglycemia either in control rats or in those exposed to stress. FFA level in the blood increased by 80% in the 3rd hr of stress alone. Moderate hypopotassaemia, although statistically insignificant, was observed throughout stress. An increased choline esterase activity in the blood serum appeared in rats subjected to stress. Under the influence of neuroleptics and stress the FFA level usually decreased, although these changes were insignificant and irregular. CPZ and TRZ lowered the K ion level very markedly.

SOURCE: Polish Journal of Pharmacology and Pharmacy 28(11): 37-47, 1976

AUTHOR(S): Hanson, H.M. and D.A. Brodie

EXPERIMENT TITLE: Use of the Restrained Rat Technique for Study of the Antiulcer Effect of Drugs

SUBJECTS: Male Holtzman albino rats (30-125 gm)

AREA OF STUDY: Digestive; Pharmacology

OBJECTIVES: In title

PROTOCOL: Rats were deprived of food for 48 hr, after which they were lightly anesthetized with ether injected ip either with the drug to be studied or an equal volume of saline. The rats were immobilized by folding and securing galvanized window screen about the animal. After 4 hr of restraint, the rats were killed immediately and their stomachs removed to determine number of lesions produced by food deprivation and restraint. Drugs given just prior to restraint were: atropine sulfate, diphenmethanil, mepiperphenidol, propantheline, scopolamine methiodide, chlorpromazine, benactyzine, pentobarbital, acetazolamide, and prednisolone.

IMMOBILIZATION METHOD: Galvanized window screen

RESULTS: Food deprivation and restraint produced a 69% ulcer incidence rate. All 5 anticholinergic drugs significantly decreased ulceration; scopolamine methiodide seemed to be the most potent drug tested, followed by propantheline, atropine, diphenmethanil, and mepiperphenidol. All 3 central nervous system depressants decreased the incidence of ulcers with no differences in potency. Daily acetazolamide administration for 5 days had no effect on ulceration. Daily prednisolone administration increased the time required for recovery from restraint-produced ulcers.

SOURCE: Journal of Applied Physiology 15: 219-294, 1960

AUTHOR(S): Hardt, A.B.

EXPERIMENT TITLE: Early Metabolic Responses of Bone to Immobilization

SUBJECTS: 26 Male white rabbits (2.7-4.1 kg)

AREA OF STUDY: Skeletal; Blood

OBJECTIVES: In title

PROTOCOL: Under anesthesia, the skin was incised 1 cm proximal to the calcaneus and a 1 cm section of the tendon was removed. After 5, 10, 15 and 18 days, blood samples from the femoral nutrient veins were collected. Measurements: blood gases; pH; calcium; phosphorus.

IMMOBILIZATION METHOD: Tenotomy

RESULTS: At 10 days posttenotomy, there was accretion of calcium and phosphorus, increased venous pH and O₂ tension, and decreased venous CO₂ tension of the femur. At 15 days, a significant increase in venous CO₂ coincided with a decrease in venous pH and O₂. At 18 days, bone calcium and phosphorus and venous pH and O₂ were significantly reduced while venous CO₂ was elevated.

SOURCE: Journal of Bone and Joint Surgery 54-A(1): 119-124, 1972

AUTHOR(S): Hayat, A., C. Tardieu, J.C. Tabary, and C. Tabary

EXPERIMENT TITLE: Effects of Denervation on the Reduction of Sarcomere Number in Cat Soleus Muscle Immobilized in Shortened Position During Seven Days

SUBJECTS: Cats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two experimental groups: Group 1) 14 cats were used to determine the shortest period of immobilization which leads to a reduction of muscle extensibility and to a significant and homogenous decrease of sarcomere number involving all the fibers within a muscle. The periods of immobilization were for 2, 4 and 7 days. Both hind limbs were immobilized by plaster casts in complete plantar flexion so that the soleus muscles were in a maximal shortened position. Group 2) 9 cats. In 7 of the animals, one soleus muscle was denervated and both hind limbs immobilized; in 2 animals, one soleus muscle was denervated but no immobilization imposed. Group 2 cats were sacrificed after 7 days. After sacrifice, the sarcomere number within the muscle fibers was determined.

IMMOBILIZATION METHOD: Plaster cast; Denervation

RESULTS: The optimal period of immobilization to produce a marked decrease in extensibility and a large reduction in sarcomere number was found to be 7 days. In the denervated and immobilized soleus muscles, muscle extensibility was normal or slightly diminished, in immobilized nondenervated soleus muscles it was strongly diminished. Denervation and no immobilization did not change sarcomere number within 7 days.

SOURCE: Journal de Physiologie 74(6): 563-567, 1978

AUTHOR(S): Weiner, L. and J. Domonkos

EXPERIMENT TITLE: Effect of Denervation and Immobilization on
Carbohydrate Metabolism in Tonic and Tetanic
Muscles. II. Oxidative Metabolism

SUBJECTS: Adult rabbits

AREA OF STUDY: Muscular; Metabolism and energy exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) denervation by unilateral section of the sciatic nerve, rabbits examined during the 5-14 day postdenervation interval; 2) immobilization by the mechanical fixation of one hind limb, rabbits examined between the 9th and 14th days of immobilization. Animals were sacrificed and the muscles immediately removed. Diet: normal. Measurements: oxygen uptake, and high energy phosphate in tonic and tetanic muscles.

IMMOBILIZATION METHOD: Denervation; Mechanical fixation

RESULTS: In the 2nd postoperative wk, significant differences in oxygen uptake of tetanic and tonic muscles were seen, with oxygen uptake decreasing in the tonic and slightly increasing in the tetanic muscles. Inactivity induced by immobilization, even 2 wk after fixation, produced no changes in oxygen uptake in either of the 2 muscles. No opposite change occurred in the high energy phosphate content of both muscles. In both kinds of muscles high energy phosphate content slightly increased on the effect of inactivation; the increase was more marked in the tonic muscle.

SOURCE: Acta Physiologica Academiae Scientiarum Hungaricae 28: 237-244,
1965

AUTHOR(S): Heiner, L., M. Stipula, and J. Domonkos

EXPERIMENT TITLE: Connection Between Carbohydrate Metabolism and Atrophy in Tonic and Tetanic Muscles

SUBJECTS: 20 Adult rabbits

AREA OF STUDY: Muscular; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Denervation was accomplished by unilateral section of the sciatic nerve. Two animals were sacrificed every 2nd day for 20 days. Histological studies were done. The soleus muscle was used as the tonic muscle; the semimembranosus as the tetanic muscle. Measurements: glycogen, non-collagenous protein and dry matter content of tonic and tetanic muscles.

IMMOBILIZATION METHOD: Denervation

RESULTS: Atrophy appeared earlier in the tonic muscle following denervation. Atrophy changes during weeks 2-3 did not follow the metabolic changes in all respects. Glycolytic metabolism appeared earlier than histologically demonstrable atrophy. Oxidative metabolism changes after atrophy became histologically distinct. Following denervation, glycolysis and oxygen uptake were inverse in both muscles. Alterations were not directly connected with atrophy.

SOURCE: Acta Physiologica Academiae Scientiarum Hungaricae 28(3): 245-252, 1965

AUTHOR(S): Helander, E.A.S.

EXPERIMENT TITLE: Influence of Exercise and Restricted Activity on the Protein Composition of Skeletal Muscle

SUBJECTS: Male guinea pigs (800-1100 gm), Rabbits (1200-1800 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Seven groups: 1) guinea pig controls; 2) guinea pigs exercised for 4 mo by running 1000 m on a motorized belt, 6 days/wk with 2 10 min pauses; 3) guinea pigs restrained in groups of 3 in a cage 22 x 35 x 24 cm; 4) rabbit controls killed at beginning of experiment; 5) rabbit controls kept for 6 mo unrestrained; 6) rabbits restrained for 6 mo in 35 x 35 x 70 cm cages; 7) rabbits restrained as group 6 for 3 yr. At the end of the experiments, all animals were killed and exsanguinated. Diet: normal, water ad libitum. In the guinea pig series, the calf muscles were excised and weighed; in the rabbits series the quadriceps femoris were excised and weighed. Histological analyses were made on these muscles. Measurements: muscle weight; water content; content of nitrogen components.

IMMOBILIZATION METHOD: Cage (guinea pigs - 22 x 35 x 24 cm; rabbits - 35 x 70 x 35 cm)

RESULTS: In guinea pigs, muscular weight rose with rising degrees of functional activity. There was no difference in water content for the control and restricted groups, but it was significantly lower in exercised animals. The three groups exhibited no significant differences with respect to sarcoplasmic proteins, stroma proteins, and non-protein nitrogen, but the exercised group showed a significantly higher myofilamental protein nitrogen content. In rabbits of all groups, the total nitrogen contents and the proportions of stroma nitrogen and non-protein nitrogen remained unaltered. The animals that were restrained showed a decrease in myofilamental nitrogen, and an increase in sarcoplasmic nitrogen content.

SOURCE: Biochemical Journal 78: 478-482, 1961

AUTHOR(S): Hemmati, M., F. Abtahi, M. Farrokhsiar, and B. Djahanguiri

EXPERIMENT TITLE: Prevention of Restraint and Indomethacin-Induced
Gastric Ulceration by Bile Duct or Pylorus Ligation
in Rats

SUBJECTS: Rats (140-180 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Six groups of 40 rats each: 1) restraint; 2) restraint plus bile administration; 3) indomethacin treatment; 4) indomethacin plus bile administration; 5) bile administration; and 6) saline solution. Subgroups of 10 rats from each group were subjected to bile duct ligation, pylorus ligation and sham operation. Rats were deprived of food for 24 hr before the experiment. Animals were restrained by placing them in a piece of galvanized steel window screen, molding the screen around the animal and holding it in place with adhesive tape. The animals' limbs were taped together. Restrained rats were kept in a cold room (4°C) for 180 min. Three hr after restraint and 4 hr after indomethacin or saline administration, the animals were killed by a blow to the head; the stomachs opened and inspected. Measurements: gastric ulceration.

IMMOBILIZATION METHOD: Galvanized steel window screen

RESULTS: Restraint or indomethacin treatment produced gastric ulceration in all sham-operated and unoperated rats. In bile-duct ligated rats, 10% of restrained and none of the indomethacin-treated rats showed ulceration; the figures were 10% and 50% in pylorus-ligated rats. The restraint and indomethacin-induced gastric mucosal ulcerations were prevented by bile duct or pylorus ligation; however, bile administration abolished the preventive effect of ligation.

SOURCE: Digestion 10(2): 108-112, 1974

AUTHOR(S): Herbison, G.J., M.M. Jaweed, and J.F. Ditunno

EXPERIMENT TITLE: Muscle Fiber Atrophy After Cast Immobilization in the Rat

SUBJECTS: 14 Adult female Wistar rats (200±25 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 6 wk immobilization - subjects were anesthetized with sodium pentobarbital, bilateral cast immobilization of plantarflexors with knee and ankle joints fixed in a neutral position; 2) controls. Measurements: muscle weight; protein content; fiber histochemistry.

IMMOBILIZATION METHOD: Cast

RESULTS: The body weight of cast animals declined significantly. There was equal weight loss in the gastrocnemius, soleus, and plantaris muscles. Sarcoplasmic and myofibrillar protein decreased 8% and 20% respectively; that of stromal protein increased 39% over controls. Loss in absolute protein amount was 64%, 69% and 49% for the sarcoplasmic, myofibrillar, and stromal proteins, respectively. Fiber atrophy of types I and II was equal in the soleus; that of type II was greater than type I atrophy in both regions of the plantaris. All soleus and 2 plantaris muscles demonstrated fiber damage.

SOURCE: Archives of Physical Medicine and Rehabilitation 59(7): 301-305, 1978

AUTHOR(S): Herner, D. and W.F. Caul

EXPERIMENT TITLE: Restraint Induced Ulceration in Rats During Estrus and Diestrus

SUBJECTS: 24 Female and 12 male Wistar rats (60 days old)

AREA OF STUDY: Digestive; Endocrine

OBJECTIVES: In title

PROTOCOL: Restraint: 19 hr. The immobilization device restrained the rat by securing the legs in grooves appropriately placed in a Plexiglas base and fitted with leg stops and clamps. There were 12 rats each in 3 experimental groups. 4 rats were chosen from each group based on vaginal smears taken; each was weighed, implanted with heart electrodes, and food-deprived for 24 hr. Following food deprivation, rats were weighed, vaginal smears taken, and restrained. Following 30 min of restraint, 20 stimuli were presented (intertrial intervals: 70, 90 or 110 sec). Heart rate was recorded for 6 sec before and during each stimulus. Following restraint, rats were sacrificed, weighed, vaginal smears taken, and examined for stomach pathology. Measurement: heart rate.

IMMOBILIZATION METHOD: Leg stops and clamps

RESULTS: After restraint, diestrus females showed greater ulceration than males while ulceration in estrus females fell between that seen in diestrus and male rats. Neither weight loss during restraint, nor heart rate measures were consistently related to the development of ulcers.

SOURCE: Physiology and Behavior 8: 777-779, 1972

AUTHOR(S): Heroux, O. and J.S. Hart

EXPERIMENT TITLE: Restraint Hypothermia and Its Inhibition by Cold
Acclimation

SUBJECTS: 19 Male white Sprague-Dawley rats (200 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) rats kept at 30°C for 2 mo; 2) kept at 6°C for 2 mo. All rats were placed under restraint in a narrow cage (5 cm wide) at 6°C for 2 hr then returned to the acclimation chamber. One wk later the procedure was repeated using a wide (8.12 cm) cage. Diet: food and water ad libitum. Measurements: rectal and skin temperature.

IMMOBILIZATION METHOD: Wire mesh cylindrical cage

RESULTS: Under restraint in a narrow cage, the 30°C acclimated rats showed a progressive fall in skin and rectal temperatures. In a wide cage, normal temperatures were maintained. In 6°C acclimated rats, restraint caused a significant decrease in skin temperature but no effect on rectal temperature. There was no correlation between body weight and degree of hypothermia of individual rats of the same acclimation group.

SOURCE: American Journal of Physiology 177: 219-221, 1954

AUTHOR(S): Hetey, L., M. Poppei, and K. Hecht

EXPERIMENT TITLE: The Effect of a Chronic Stress on the Energy Metabolism of Cortical Synaptosomes in Rats

SUBJECTS: Male Wistar rats (200-240 gm)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Rats were kept hypokinetic for 6 and 12 wk during which their blood pressure was constantly measured. They were divided into 2 groups, hypertonic (blood pressure raised to maximum extent) and normotonic (unchanged blood pressure). An additional control group was included. Synaptosomes of the neocortex were isolated and incubated with U-¹⁴C-glucose. A synaptosome is a practically autonomous cell without a nucleus (with at least one mitochondrion), which is capable of independently performing the basic metabolic processes. Admission of O₂ and release of CO₂ were measured. The separation of the HClO₄ extract, determination of the concentration of participating metabolites and the percentage of their penetration into the organism were performed.

IMMOBILIZATION METHOD: Not stated

RESULTS: Oxygen consumption in incubated synaptosomes of control rats was 48 micromole of O₂/100 mg of synaptosomal protein per 1 hr. One wk of restraint led to a significant reduction (by 2 times) in oxygen consumption. During succeeding stress, it increased to 2/3 the normal amount. There were no differences in the nature of the change in synaptosomal metabolism between the hypertonic and normotonic groups. The onset of stress caused a decrease of 20% in the anerobic decomposition of glucose. Subsequently, the insignificant increase in the percentage of glucose absorption corresponded to a sharp rise in the lactate from endogenous substances (130% of initial amount).

SOURCE: Zhurnal Vysshei Nervnoi Deiatelnosti 27(2): 352-354, 1977

AUTHOR(S): Hines, H.M. and G.C. Knowlton

EXPERIMENT TITLE: Electrolyte and Water Changes in Muscle During Atrophy

SUBJECTS: 150 Adult rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Gastrocnemius muscles. Atrophies were produced by: 1) fasting - deprivation of all food except water for 8 days; 2) denervation - removal of section of sciatic nerve (1 cm); 3) fasting concomitant with denervation; and 4) tenotomy - oscaalis chipped off and sewn to sutured skin. Measurements: muscle weight, water content; amount of chlorides, potassium and calcium.

IMMOBILIZATION METHOD: Denervation; Tenotomy

RESULTS: Muscular atrophies caused by denervation, fasting and tenotomy were associated with an increased chloride concentration which paralleled the extent of atrophy. All degrees and types of atrophy were accompanied by slight but consistent increases in total water content. The concentration of acid-soluble phosphorus and potassium in atrophic muscles decreased by amounts which paralleled the degrees of atrophy; calcium content increased in atrophic muscles.

SOURCE: American Journal of Physiology 120: 719-723, 1937

AUTHOR(S): Hoffman, R.A., E.A. Dozier, P.B. Mack, W.N. Hood, and M.W. Parrott

EXPERIMENT TITLE: Physiologic and Metabolic Changes in *Macaca nemestrina* on Two Types of Diets During Restraint and Non-restraint:
I. Body Weight Changes, Food Consumption and Urinary Excretion of Nitrogen, Creatine and Creatinine

SUBJECTS: *Macaca nemestrina* (7.4-8.4 kg)

AREA OF STUDY: Fluid and Electrolyte; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Four groups: 1) control, non-restrained and Diet A; 2) restrained and Diet A; 3) non-restrained and Diet B; 4) restrained and Diet B. The 'restrained' primates were strapped in couches (a hammock of nylon net strung in a rectangular aluminum frame) for 35 days with a subsequent exposure to a Biosatellite simulated reentry profile with centrifugation to 12-G, followed by a 35-day period of post-restraint on the same diet. The non-restrained groups remained in metabolism cages except on the 35th day when they also were exposed to the reentry profile. Diet B was superior in all nutrients (except protein) for which analyses were made; Diet B had three times as much calcium and almost one and one-half times as much phosphorus as Diet A. The two diets were similar in provision of energy. Measurements: body weight; nitrogen, creatine and creatinine in daily samples of urine.

IMMOBILIZATION METHOD: Couch

RESULTS: Restraint and Diet A brought about a greater loss in body weight than was found in the unrestrained animals on the same diet. During simultaneous introduction of Diet B and restraint, restraint had the overriding effect, with the diet serving to modify the effect of restraint on body weight to some extent. Excretion of urinary creatine was greatly increased in both dietary groups during restraint with the formerly restrained groups approaching a reduced creatine excretion level during the recovery period. Creatinine excretion which was relatively constant in the unrestrained dietary group was disturbed during restraint and post-restraint in the restrained animals, apparently because of the highly increased creatine excretion during restraint. As the post-restraint or recovery period progressed, creatinine excretion was tending to approach the initial level. There were no significant dietary differences in the non-restrained primates throughout, although the animals on Diet B excreted higher amounts of urinary creatinine throughout both periods of the study.

SOURCE: Aerospace Medicine 39: 693-698, 1968

AUTHOR(S): Höpker, W.-W., W. Hofmann, J. Weiss, R. Zimmermann, E. Walter, H.-As. Dittmar, and A. Weizel

EXPERIMENT TITLE: The Effect of Acetylsalicyclic Acid, Extremely Restricted Movement and a Cholesterol-Rich Diet on Atheromatosis of the Rabbit Aorta: Comparative Investigations

SUBJECTS: 40 Male graysilver rabbits, 13-15 wk (2.7 kg)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Eight groups of 5 animals each; various combinations of diet (normal, atherogenic, fiber-enriched, and mixed), immobilization, and usage of acetylsalicyclic acid (ASA): 1) normal diet only; 2) atherogenic diet, immobilization, and ASA; 3) atherogenic diet and immobilization; 4) normal diet, immobilization, and ASA; 5) normal diet and immobilization; 6) fiber-enriched diet and immobilization; 7) mixed-diet only; and 8) atherogenic diet only. 90 day experiment duration. Diet: ad libitum. The daily doses of ASA were between 250 and 450 mg, a total average of at least 100 mg/kg per day. Blood samples were taken 4 times at regular intervals. Measurements: body weight; cholesterol; triglycerides; hematocrit; leucocytes; spontaneous thrombocyte aggregation; thrombocyte count; thromboplastin time; morphological studies of the aorta.

IMMOBILIZATION METHOD: Cage with adjustable side walls

RESULTS: The increase in weight of the experimental animals was not significantly different in various groups. Serum cholesterol showed considerable variations in all groups; increased values, however, were only found in the experimental groups receiving an atherogenic diet. Increased cholesterol levels were not found in animals immobilized without atherogenic diet. Other factors: serum triglycerides - no differences independent on cholesterol level; leucocyte count - unchanged; hematocrit value - definite differences between subjects receiving cholesterol and fat-rich diets and those with normal or fiber-enriched diets; spontaneous thrombocyte aggregation - no pathological shifts in groups receiving no ASA and those with atherogenic diet; thrombocyte counts - no significant differences; thromboplastin time - no significant differences. Experimental animals demonstrating any endothelial proliferations all received atherogenic diets. ASA had no influence on the degree of atheromatosis of the aorta in the case of the atherogenic diet and immobilization. With and without ASA no group differences were ascertained in the case of normal diet and immobilization.

SOURCE: Virchows Archiv. A. Pathological Anatomy and Histology No.367: 307-323, 1975

AUTHOR(S): Hrubes, V. and V. Benes

EXPERIMENT TITLE: The Time Course of Metabolic Changes During Prolonged Stress in Rats

SUBJECTS: Female rats (150-180 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Immobilization: 24 hr. Two series of experiments were performed. The first series included 2 experimental groups: 1) 18 rats partially restrained in a small wire cage corresponding with the body shape (6 controls); 2) 15 rats completely immobilized by means of bandages and adhesive tapes (5 controls). Animals were fasted the day prior to and during immobilization. Nonesterified fatty acids (NEFA) values were determined initially and after 18 and 24 hr of immobilization. After termination of each experiment the rat's gastric mucosa was examined. In the second series of experiments catecholamines in tissues were studied (norepinephrine and dopamine in the brain and epinephrine in the adrenal glands). 13-18 rats were immobilized using the same restraint procedures as the first series (13-18 control rats). After termination of each experiment biochemical tests were made.

IMMOBILIZATION METHOD: Wire cages; Bandages and adhesive tape

RESULTS: The immobilized animals showed a significant rise in serum NEFA in both groups. The values of NEFA were almost regularly higher after 18 hr than after 24 hr immobilization. After complete immobilization (bandages and adhesive tape) the rise was greater. Dopamine and norepinephrine decreased in the immobilized animals. A similar trend was observed in the adrenals where epinephrine decreased markedly in both groups.

SOURCE: Journal of Psychosomatic Research 13: 327-331, 1969

AUTHOR(S): Hulth, A. and S. Olerud

EXPERIMENT TITLE: Disuse of Extremities I: An Arteriographic Study
in the Rabbit

SUBJECTS: Rabbits (2-3 kg)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: The left hind limb of the experimental animals was inactivated by: 1) section of the sciatic nerve; 2) section of the femoral nerve distal to the inguinal ligament combined with intrapelvic section of the obturator nerve; 3) plaster immobilization applied to half way up the thigh and embracing the whole foot; 4) resection of 1 to 1-1/2 cm of Achilles tendon; 5) induction of aseptic arthritis in the knee joint or ankle by injecting turpentine locally; or 6) amputation of the lower leg at the junction of the upper and middle thirds. Arteriography was performed at varying intervals after the infliction of the experimental lesion.

IMMOBILIZATION METHOD: Denervation; Cast

RESULTS: Arteriograms showed characteristic appearances common to all the different forms of experimental disuse. These consisted in dilatation and tortuosity of the vessels and in some cases an early venous return, suggesting a rise in the rate and probably also in the volume of the blood flow.

SOURCE: Acta Chirurgica Scandinavica 120: 220-226, 1960

AUTHOR(S): Hulth, A. and H. Semb

EXPERIMENT TITLE: Acid-Base Status of the Intramedullary Blood
in Immobilized Extremities: A Preliminary Report

SUBJECTS: Rabbits (2 kg)

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: The left hind leg was immobilized in one of 3 ways: 1) resection of one centimeter of the calcaneus tendon; 2) resection of the sciatic nerve; or 3) fixation of the leg in plaster of Paris, with the knee joint in the flexed position and the ankle joint in the intermediate position. After periods of immobilization (4 days to 4 wk), the animals were anaesthetized with Nembutal and heparinized. They were then connected via a tracheotomy to a respirator and breathed atmosphere air. Arterial blood was obtained from the common carotid artery, and the blood from the tibia was sampled and analyzed. Measurements: pH; pCO₂.

IMMOBILIZATION METHOD: Plaster of Paris cast; Denervation; Tenotomy

RESULTS: There was a clear tendency to higher pH values in intramedullary blood from the immobilized tibia for periods of immobilization longer than 10 days. The standard bicarbonate values in blood from the right and left tibia showed no certain variations. The pCO₂ was lower on the immobilized side. Some cases demonstrated a general metabolic acidosis.

SOURCE: Acta Orthopaedica Scandinavica 37: 117-121, 1966

AUTHOR(S): Huszti, Z. and T.L. Sourkes

EXPERIMENT TITLE: Uptake and Metabolism of Histidine During Stress

SUBJECTS: Male Sprague-Dawley rats (150-160 gm)

AREA OF STUDY: Respiratory; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Animals were starved for 18-24 hr before the experiment. Rats were restrained by wrapping them in plaster bandages; they were kept at room temperature or 4°C for 1 or 2 hr. They were then injected ip with a radioactive compound L-histidine- $^{14}\text{COOH}$ (C-his), DL-dopa- $^{14}\text{COOH}$ (C-Dopa), L-glutamic acid (U-Glu), L-histidine-ring 2- ^{14}C (R-His), or L-urocanic acid-ring 2- ^{14}C (R-Uro) and placed in metabolism cages at 23°C for collection of $^{14}\text{CO}_2$. Measurements: histidase and histidine decarboxylase activity.

IMMOBILIZATION METHOD: Plaster bandage

RESULTS: Rate of $^{14}\text{CO}_2$ expiration by restrained rats given C-His was significantly increased over control values; that from R-His was decreased. In restrained and cold-stressed rats the $^{14}\text{CO}_2$ formation rate from C-His decreased; that from R-His showed an even greater decrease. Stress procedures did not significantly alter the formation rate of labeled CO_2 from R-Uro. Enzyme activities of histidine catabolism in rats restrained 2 hr at room temperature showed no alteration in histidine activity of liver and lungs, but there was a marked increase in the histidine decarboxylase activity of the stomach. 1-hr cold exposure during restraint resulted in enhanced histidine decarboxylase activity but of a lesser degree; 2-hr cold exposure during restraint abolished the difference between controls and stressed rats noted at room temperature. Both groups of stressed animals (restraint at room and cold temperatures) had much higher serum histidine levels than in controls.

SOURCE: Canadian Journal of Biochemistry 52: 782-788, 1974

AUTHOR(S): Ilina-Kakuyeva, Ye.I. and V.V. Portugalov

EXPERIMENT TITLE: State of Rat Motoneuron System in the Case of
Restricted Mobility

SUBJECTS: White mongrel male rats

AREA OF STUDY: Nervous; Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) restricted mobility for 7, 15, 30, 45 and 65 days, 10 rats for each testing time, small individual cages; 2) controls. Measurements: neurohistochemical examinations of the motor nerve endings.

IMMOBILIZATION METHOD: Cage

RESULTS: The study of the soleus muscle revealed changes which resulted in the formation of so-called target fibers and partial death of muscle fibers, as well as changes in the nerve endings. These changes seemed to be destructive throughout the 7-15 day hypokinetic period and reparative during 30-65 hypokinetic days. The study of the gastrocnemius muscle did not demonstrate any structural changes in motor patches.

SOURCE: Space Biology and Aerospace Medicine 11(6): 39-44, 1977

AUTHOR(S): Imig, C.J., B.F. Randall, and H.M. Hines

EXPERIMENT TITLE: Effects of Immobilization on Muscular Atrophy
and Blood Flow

SUBJECTS: Adult dogs

AREA OF STUDY: Muscular; Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) immobilization of one hind limb (shortened or lengthened position) in plaster cast, the normal contralateral limb served as a control; 2) unilateral denervation of the hind limb by sectioning the sciatic nerve at the level of the trochanter and by cutting the femoral nerve at the ligament of Poupart. In both groups, the animals were sacrificed at the end of 14 days; the gastrocnemius muscles were dissected out. Measurements; muscle weight; volume of blood flow; temperature of gastrocnemius muscle.

IMMOBILIZATION METHOD: Plaster cast; Denervation

RESULTS: Immobilization caused a significant increase in volume of blood flow and persisted following cast removal; the increase was similar in both limb positions. Atrophy in the immobilized gastrocnemius muscles was comparable to that found after denervation. Gastrocnemius muscle temperature under restraint was an average of 0.5°C higher than in the control limb.

SOURCE: Archives of Physical Medicine and Rehabilitation 34: 296-299, 1953

AUTHOR(S): Imondi, A.R., M.E. Balis, and M. Lipkin

EXPERIMENT TITLE: Nucleic Acid Metabolism in the Gastrointestinal Tract of the Mouse During Fasting and Restraint-Stress

SUBJECTS: 48 Male CFW mice (25-27 gm)

AREA OF STUDY: Digestive; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Each of the experimental groups contained 4 normal, 4 fasted and 4 restrained animals. Restrained mice were secured in wire mesh screen. Mice were injected with either 20 μ c thymidine methy-³H (Exp. 1 & 2) or 10 μ c uridine-5-³H (Exp. 3 & 4) after 16 hr or 40 hr of fasting or restraint. Animals sacrificed 1 hr after injection, preparation of tissue samples were made from glandular stomach, duodenum, mid-jejunum, terminal ileum, and proximal colon. Measurements: uptake of thymidinemethy-³H (TdR-³H) and uridine-5-³H (UR-³H) into DNA and RNA of tissues.

IMMOBILIZATION METHOD: Wire mesh screen

RESULTS: Fasting had little effect on DNA or RNA metabolism in the gastrointestinal tract except for increases in the uptake of UR-³H in the small intestine. Restraint caused a reduction in DNA synthesis along the entire gastrointestinal tract and affected RNA metabolism in the stomach, but not in the small intestine or colon. Changes in the stomach included early loss of total RNA followed by a decreased in the uptake of UR-³H. The latter appeared to coincide with the occurrence of gastric erosions.

SOURCE: Experimental and Molecular Pathology 9(3): 339-348, 1968

AUTHOR(S): Imondi, A.R., M.E. Balis, and M. Lipkin

EXPERIMENT TITLE: Effects of Restraint-Stress on Enzymes Involved
in DNA Synthesis

SUBJECTS: Male CFW mice (25 gm)

AREA OF STUDY: Metabolism and Energy Exchange; Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental mice were restrained in a wire mesh screen for 4 hr. All mice were injected ip with 20 μ Ci thymidine-methyl-3H, and killed 1 hr later. The glandular stomach and jejunum were removed. Measurements: enzymes; thymidine kinase; aspartate carbamoyltransferase; DNA nucleotidyltransferase.

IMMOBILIZATION METHOD: Wire mesh screen

RESULTS: There was a significant decrease in the incorporation of thymidine-methyl-3H into DNA of stomach and jejunum after subjecting mice to restraint. Changes in enzyme levels were not responsible for decreased DNA synthesis resulting from restraint stress.

SOURCE: Proceedings of the Society for Experimental Biology and
Medicine 131: 376-379, 1969

AUTHOR(S): Inchina, V.I.

EXPERIMENT TITLE: Effects of Hypodynamia on the Hemocoagulative Properties of the Vascular Wall and Myocardium

SUBJECTS: 24 Chinchilla rabbits (2-3 kg)

AREA OF STUDY: Circulatory; Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 14 rabbits, hypodynamia for 7 days; 2) 10 controls. Measurements: hemocoagulation qualities of the aorta, myocardium and hollow veins, fibrinolytic quality by euglobulin method.

IMMOBILIZATION METHOD: Not stated

RESULTS: The myocardium, all layers of the aorta and the hollow veins of the rabbits exhibited a rather high degree of thromboplastic, anticoagulant and fibrin-stabilizing activity. There was little fibrinolytic activity of the tissues in these animals.

SOURCE: Kardiologia 18(3): 126-129, 1978

AUTHOR(S): Ishii, Y., C. Mimura, and M. Homma.

EXPERIMENT TITLE: Effect of Dopamine- β -Hydroxylase Inhibitors on Blood Pressure and Cardiac Norepinephrine Levels in Rats Subjected to Immobilization Stress

SUBJECTS: Male spontaneously hypertensive rats (SHRs);
male normotensive control rats (NCRs) (all 15-18 wk old)

AREA OF STUDY: Circulatory; Pharmacology

OBJECTIVES: In title

PROTOCOL: Rats were restrained on their backs by tying legs and foreteeth to a board for 2 hr. Prerestraint: blood pressure was measured via chronic aorta cannula; 100mg/kg calcium salt of fusaric acid and FD-008 was suspended in .5% carboxymethylcellulose and given orally via stomach tube 4 hr prestress. Measurements: blood pressure; cardiac norepinephrine (NE); heart rate.

IMMOBILIZATION METHOD: Board

RESULTS: Blood pressure in the NCRs rose immediately after the onset of stress; in the SHRs, blood pressure did not rise after stress despite a marked heart rate increase. Fusaric acid or FD-008 markedly inhibited the increase in blood pressure by stress in the NCRs and decreased blood pressure in the SHRs. Heart rate increase in the SHRs during stress was completely inhibited by FD-008 but not in the NCRs. Restraint decreased endogenous NE levels in the heart in the NCRs and SHRs, and FD-008 induced further significant decreases in NE levels in the SHRs and NCRs or fusaric acid in the SHRs. The FD-008 effect was greater than the fusaric acid effect. Effects of picolinic acid derivatives on blood pressure and cardiac NE levels were more remarkable in a stressed state than in a resting state.

SOURCE: Journal of Pharmacology and Experimental Therapeutics 198(3): 589-595, 1976

AUTHOR(S): Jaffe, D.M., R.D. Terry, and A.J. Spiro

EXPERIMENT TITLE: Disuse Atrophy of Skeletal Muscle. A Morphometric Study Using Image Analysis

SUBJECTS: 24 Male Sprague-Dawley rats (110 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: The right leg was immobilized by surgical pinning of the knee and ankle joints. The left leg served as the control. Animals were killed at 1, 3, 7 and 13 days after pinning. The anterior tibialis muscle was removed, thin cross-sectional coverslips were made, and then were stained using a modified myosin-ATPase reaction which defined three types of muscle fiber: light, medium and dark. A computerized image analyzing apparatus was used to analyze the muscle specimens. Measurements: area of each of the three types of fibers.

IMMOBILIZATION METHOD: Internal fixation with needles

RESULTS: Because the rats were in a high growth-rate stage of development, atrophy was measured as the ratio of growth of the immobilized limb to growth of the normal limb. The dark fibers, the richest in ATPase, showed an almost insignificant atrophy, while the light fibers, which were ATPase negative, showed a great deal of atrophy. Medium fibers showed an intermediate degree of atrophy.

SOURCE: Journal of Neurological Sciences 35: 189-200, 1978

AUTHOR(S): Jankovich, J.P.

EXPERIMENT TITLE: Structural Development of Bone in the Rat Under Earth Gravity, Simulated Weightlessness, Hypergravity and Mechanical Vibration

SUBJECTS: Male Sprague-Dawley rats, 60 days old

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: A plaster cast was put on the right leg of the rats under general Nembutal anesthesia. The cast surrounded the leg completely and was extended in a funnel shape to partially cover the pelvis. The leg was immobilized for 5 wk then the cast removed under general anesthesia. Exposure to centrifugation and vibration started 3 days later. Only 1 leg was immobilized to make the following 3 comparisons: 1) at earth gravity, immobilized bone vs. free bone; 2) under hypergravity or vibration, immobilized bone vs. free bone; 3) immobilized bone at earth gravity vs. immobilized bone under hypergravity or vibration. Hypergravity and vibration studies without cast immobilization were also performed but will not be reported in this summary. Diet: Purina Laboratory Chow and water ad libitum; food supplement containing ground oyster shell mixed with melted sugar. Rats were successively sacrificed; mineralization was traced by administration of tetracycline; radiographic densitometry was used in vivo and in vitro to follow bone development. Measurements: bone weight; geometry (volume, length, cross-sectional area); density; compressive elasticity; torsional elasticity; microhardness; sound conductivity; histological solidity; ash content; calcium content; mode of mineralization.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: Immobilization significantly influenced body weight and development. The rate of body weight growth was significantly slower than normal. The development of some bone parameters was also retarded: weight, volume and density consistently had lower values during immobilization. Ash and calcium content of immobilized knee was reduced compared to the normal knee. Growth of the cross-sectional area was retarded in the knee joint only. Compressional and torsional rigidity and microhardness became higher than normal during immobilization. Most effects of immobilization disappeared within 5 wk after removal of the cast. Exposure to hypergravity and vibration, following immobilization, retarded the growth of body weight, but did not interfere with subsequent return of all bone parameters to normal levels.

SOURCE: National Aeronautics and Space Administration, Washington, D.C., October 1971, 141 pp. (NASA CR-1823)

AUTHOR(S): Jarvinen, M.

EXPERIMENT TITLE: Immobilization Effect on the Tensile Properties of Striated Muscle: An Experimental Study in the Rat

SUBJECTS: 40 Male albino rats Wistar strain (263-363 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Immobilization: 3 wk total duration. The rats were anesthetized, and the left hind leg was immobilized with a padded plaster cast from the toes to about 1 cm above the knee; right leg served as control. Diet: laboratory chow and water ad libitum. Groups of 10 rats each were killed with ether on days 7, 14, 21 and 42 to produce complete muscle relaxation; strength measurements were made within 20 minutes after death. Measurements: body and muscle weight; rupture site; strength parameters - breaking strength, maximal linear strength, elongation at breaking strength, elastic stiffness, energy absorption (W max and W lin, i.e. work required to achieve the breaking strength and maximal linear strength, respectively).

IMMOBILIZATION METHOD: Plaster cast

RESULTS: The rats initially lost weight, the per cent decrease in body weight on days 7 and 14 was 13% and 10% respectively; subsequently, they gained weight, the rats studied on days 21 and 42 were about 7 and 10% heavier than the first day. There was a continuous decrease in gastrocnemius muscle weight ranging from 20% on day 7 to about 30% on day 21; after removing the casts the muscles gained in weight. The rupture always occurred at the muscle belly. The breaking strength diminished by about 20% after 1 wk; this reduction continued evenly to about 32% at the end of the immobilization period with some reduction in maximal linear strength. The initial length did not change between immobilized and control muscles, but the difference in elongation at breaking strength point between left and right muscles was significant (about 24%) on days 14 and 21. Elastic stiffness decreased during immobilization but thereafter rose close to the control level. The energy absorption capacity was strongly decreased; the average decrease in W max was 34.4% on day 7 and 45.8% at the end of immobilization. After cast removal these values began to rise similarly to those of the breaking strength and maximal linear strength but had not reached control levels on day 42. The breaking strength and corresponding energy absorption capacity were reduced more than the values of maximal linear strength and this energy absorption capacity.

SOURCE: Archives of Physical Medicine and Rehabilitation 58: 123-127, 1977

AUTHOR(S): Jönsson, L. and G. Johansson

EXPERIMENT TITLE: Cardiac Muscle Cell Damage Induced by Restraint Stress

SUBJECTS: 37 Crossbred pigs of Yorkshire and Swedish Landrace (85-90 kg)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) restraint stress created by injecting 28 pigs with succinylcholine (.14 mg/kg), respiratory activity was maintained by continuous infusion of succinylcholine chloride for 15-20 min, and simultaneously stimulated 5-6 times by an electric prod; 2) 9 controls. 16-48 hr later, both groups were slaughtered. Histochemical and electron microscopical study made of heart, myocardium and coronary vessels. Measurements: activity of succinic dehydrogenase (SDH), lactic dehydrogenase (LDH), DPN-diaphorase and cytochrome oxidase; myocardial lesions.

IMMOBILIZATION METHOD: Drug

RESULTS: The damaged muscle fibers exhibited an initial increase in formazan deposits and then a decrease and total loss of enzymatic activity. Accumulation of lipids and a reduction or total loss of glycogen was found in the damaged myocardium. Within the degenerating and necrotic areas the changes ranged from clumping to complete lysis of the myofilaments. Swelling of the SR and T system was observed, as well as inflammatory cells with dilated cisterns of rough-surfaced endoplasmic reticulum.

SOURCE: Virchows Archiv. B. Cell Pathology 17: 1-12, 1974

AUTHOR(S): Juráni, M., P. Výboh, D. Lamosová, and J. Nvota

EXPERIMENT TITLE: Effect of Restraint Upon Hypothalamic and Adrenal Catecholamines in Japanese Quail

SUBJECTS: Male Japanese Quail, 3 mo old (~98 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Eight groups: 1) controls; 2) restraint for 10 min; 3) restraint for 30 min; 4) restraint for 2 hr; 5) restraint for 4 hr; 6) restraint for 8 hr; 7) restraint for 24 hr; 8) restraint for 48 hr. Animals were restrained in small cages of approximately body size. When required, the birds were decapitated, blood was centrifuged, hypothalamus and adrenals were isolated. Measurements: levels of catecholamine from blood plasma; level of adrenal phenylethanolamine-N-methyl transferase (PNMT) from right adrenal; level of adrenaline from left adrenal and hypothalamus; level of dopamine and noradrenaline from hypothalamus.

IMMOBILIZATION METHOD: Cage

RESULTS: Hypothalamic catecholamines decreased after 10 min restraint, but returned to initial value after 30 min and remained there throughout the 48 hr stress. Dopamine also decreased after 10 min, but increased from 4 hr on. Concentration of plasma catecholamines significantly increased at 10 min of restraint and lasted to the 2nd hour whereupon it decreased to control value. The content of adrenal catecholamines decreased only very slightly during restraint. Adrenal PNMT activity began to increase after 8 hr and continued to increase through the 48 hr.

SOURCE: British Poultry Science 19: 321-325, 1978

AUTHOR(S): Kaciuba-Uscilko, H., E. Pohoska, and S. Kozlowski

EXPERIMENT TITLE: Metabolic Effects of Prolonged Restriction of Physical Activity in Rats

SUBJECTS: Wistar rats

AREA OF STUDY: Endocrine; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Three phases of immobilization experiment: 1) 1 wk control phase; 2) immobilized in hypokinetic cages up to 6 wk; 3) another control phase after removal from cages. The metabolic and hormonal consequences of exposure of rats to cold during immobilization were also studied. Measurements: body weight; resting metabolic rate; secretory activity of the adrenal and thyroid glands; rectal temperature.

IMMOBILIZATION METHOD: Cage (wire restraint)

RESULTS: The investigations revealed that during immobilization the resting metabolic rate increased considerably and weight gains were markedly reduced. Adrenaline was found to be the hormone involved in the above effect. In the immobilized rats an increased diuresis and calcium excretion were found and skeletal decalcification was noted. All of the above changes disappeared very slowly after returning the animals to normal conditions.

SOURCE: Artificial Satellites 11(1): 3-8, 1976

AUTHOR(S): Kaleta, Z., M. Grojec, and T.E. Wroblewski

EXPERIMENT TITLE: Some Metabolic and Ionic Responses During Experimental Immobilization

SUBJECTS: Rabbits (3 kg)

AREA OF STUDY: Blood; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rabbits were immobilized in metabolic cages for a period of 5 wk. Measurements: basal metabolic rate (BMR); protein-bound iodine (PBI) in blood serum; uptake and excretion of sodium and potassium; glucose induced SDA was calculated.

IMMOBILIZATION METHOD: Cage (metabolic)

RESULTS: With increasing duration of immobilization a gradual rise was observed in BMR as well as SDA values. The immobilization did not influence the level of PBI in blood serum or sodium and potassium balances.

SOURCE: Artificial Satellites 11(1): 9-14, 1976

AUTHOR(S): Karpati, G. and W.K. Engel

EXPERIMENT TITLE: Correlative Histochemical Study of Skeletal Muscle After Suprasegmental Denervation, Peripheral Nerve Section, and Skeletal Fixation

SUBJECTS: 64 Female Hartley and NIH guinea pigs

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Four groups: 1) controls; 2) 17 adult and 2 newborn, subjected to section of the spinal cord at the 7th thoracic vertebra; 3) 2 adult and 2 newborn, subjected to section of the spinal cord and also a left sciatic neurectomy; 4) 4 adult and 4 newborn subjected to skeletal fixation by pinning the right rear ankle joint to a flat surface. All animals were sacrificed following the procedure at these intervals: 3, 7, 10, 20, 30, 60, 90 and 120 days. The medial and lateral heads of gastrocnemius and soleus muscles were removed, mounted for observation of transverse section, and then stained with a battery of histochemical reactions. Measurements: muscle fiber diameters; designation of histochemical muscle fiber type, type I or II.

IMMOBILIZATION METHOD: Cordotomy; Cordotomy and Denervation; Skeletal fixation

RESULTS: Controls showed no atrophy of type I or type II fibers in the gastrocnemius, no cytoarchitectural changes in the soleus, with 0% type II fibers in the adults, and 60% in the infants. Skeletal fixation subjects showed only a slight atrophy, no cytoarchitectural changes, but a marked drop in overall percent of type II fibers in the newborn, 35%. Cordotomy subjects showed a greater degree of atrophy in both type I and type II fibers, a great deal of cytoarchitectural changes, especially in the adults, and a very high increase in the percent of type II fibers in adults. Denervation subjects showed a much greater degree of atrophy in type II fibers than in type I fibers, no cytoarchitectural changes, and a decrease in the percent of type II fibers in the newborn only.

SOURCE: Neurology 18: 681-692, 1968

AUTHOR(S): Karupu, V.Ya. and A.I. Ferents

EXPERIMENT TITLE: Effect of Hypokinesia and Physical Loadings on Cardial Myocyte Ultrastructure

SUBJECTS: 138 Rats and rabbits

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Six groups: 1) intact rats; 2) intact rabbits; 3) rats immobilized for 1 mo; 4) rabbits immobilized for 1-7.5 mo; 5) intact rabbits given a single running load to capacity; 6) rabbits - hypokinesia and given a running load to capacity. Measurements: light optical analysis of internal organs and skeletal muscles; walls of the four chambers of the heart by electron microscopy and histochemical methods.

IMMOBILIZATION METHOD: Cage

RESULTS: There was an increasing disturbance in the ultrastructure of the protein synthesizing myocardiocyte apparatus, and a reduction of the cardiac functional reserves. Loading produced diverse ultrastructural changes in the myocardium depending on the initial adaptive level to motor activity. In rabbits with satisfactory adaptation to motor activity, the loading resulted mainly in exhaustion of their energy supply; in disadapted animals it produced severe lesions in the contractile apparatus of the cardial myocytes.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 74(1): 28-37, 1978

AUTHOR(S): Kasimtsev, A.A.

EXPERIMENT TITLE: Effect of Gravitational Overloads, Hypokinesia and Hypodynamia on the Vessels of the Pulmonary Blood Circuit

SUBJECTS: 148 Male rabbits (2-2.5 kg)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Four groups: 1) 15 controls; 2) 26 rabbits subjected to single prolonged threshold endurable gravitational overloads in the chestback direction; 3) 50 rabbits subjected to hypokinesia and hypodynamia in narrow cages for 1-8 wk and then sacrificed; 4) 57 rabbits were subjected to group 1 overload following hypokinesia and hypodynamia for 1-8 wk. The pulmonary circulation vessels were studied by roentgenography and microroentgenography.

IMMOBILIZATION METHOD: Cage (narrow)

RESULTS: In exposure to gravitational stress the distal portions of the arterial vessels of the III and IV orders became constricted, while all veins dilated. Sinuosity of all vessels noted. The volume of the capillary bed increased. Signs of perivascular edema occurred. Due to hypokinesia and hypodynamia the arteries constricted and the arterial bed became poor. The veins of all orders dilated and the volume of the capillary bed increased. The changes grew greater the longer the terms of hypodynamic effects. Successive combination of hypokinesia and hypodynamia and gravitational stresses caused more pronounced changes than separate effects of these two factors and resulted in great deformity of the vascular walls, including their rupture and penetration of formed elements beyond the limits of the vascular bed.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 64(2): 82-90, 1973

AUTHOR(S): Katinas, G.S. and A.N. Potapov

EXPERIMENT TITLE: Changes in Skeletal Muscles Associated with Inactivity

SUBJECTS: Albino male rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two series: 1) 27 experimental animals were placed in small cages and examined after 15, 30, 45, 60 and 90 days (same number of controls); 2) 11 experimental animals had one of their forelegs amputated at the boundary between the middle and proximal third, studies conducted 6 mo after amputation (10 intact controls). Measurements: body weight before and after removal of skin; subcutaneous cellular tissue; weight of internal organs; weight of muscles.

IMMOBILIZATION METHOD: Cage; Amputation

RESULTS: A slow weight gain and reliable retardation of all muscles was observed in confined animals. Muscle weight was found to vary according to test duration. In the amputated animals, muscle weight and size increased on the amputated side. There was an absence of severe histological disturbances in general muscular structure.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 11: 74-81, 1971

AUTHOR(S): Katinas, G.S., V.S. Oganov, and A.N. Potapov

EXPERIMENT TITLE: Hypodynamic and Hypokinetic Condition of Skeletal Muscles

SUBJECTS: Mongrel albino rats

AREA OF STUDY: Muscular

OBJECTIVES: The effects of unilateral brachial amputation on the physiological characteristics of two functionally different muscles, the brachial muscle (flexor of the brachium), and the middle head of the brachial triceps muscle (extensor of the brachium).

PROTOCOL: Two groups: 1) left brachial amputation of 18 rats; 2) 18 controls. Measurements (taken from 3 to 6 mo following operation, under conditions of acute experiments in situ): muscle weight; body weight; time and force characteristics of single and tetanic responses of the brachial muscle and of the medial head of the brachial triceps of the operated and contralateral extremities in both groups.

IMMOBILIZATION METHOD: Brachial amputation

RESULTS: The middle head of the brachial triceps muscle weighed less than the contralateral by 27%, and 33% less than the control; the weight of the operated brachial muscle was the same as that of the contralateral and control. A diminution in the half-time of development of tetanic pressure and a drop in the amplitude of tetanic responses occurred in the operated middle head of the triceps muscle. In the operated brachial muscle there was a lengthening of the half-time of development and the half-time of decay of the tetanic response, a drop in its amplitude, and a reduction in the frequency of fused tetanus as compared with control. In the contralateral extremities, the middle head of the triceps showed an increase in the half-time for reduction of tetanic pressure and a decrease in the frequency of fused tetanus; the humeral muscle showed an increase in the half-life of single response pressure and the half-life of the tetanic response, a drop in its amplitude, and a reduction in the frequency of fused tetanus, as compared with control.

SOURCE: Fiziologicheskii Zhurnal SSSR Imeni I M Sechenova 60(10): 1606-1608, 1974

AUTHOR(S): Kato, Y.

EXPERIMENT TITLE: Studies on Muscle Atrophy Induced by Plaster Cast

SUBJECTS: White male rabbits (2.3-3.0 kg)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: The rabbits limbs were immobilized in plaster casts from the toe to the middle of the thigh. Two groups: 1) knee and ankle flexed to maximal degree; 2) knee flexed to maximal degree and the ankle extended to maximal degree. The experiments were carried out on the calf-muscle and the tibialis anterior muscle. Measurements: muscle weight; tension.

IMMOBILIZATION METHOD: Cast

RESULTS: Muscle weight - 1) calf: after 30 days the reduction in weight of group 1 muscle proceeded rapidly, and around 40 days the weight was approximately 60% of the contralateral side; after 40 days the rate of weight reduction decreased. The weight loss of group 2 proceeded rapidly in the early days and within 20 days its weight became approximately 60% of the contralateral side. 2) tibialis anterior: weight of group 2 was 150% that of control at day 20, after which this tendency was reversed and within 30 days of immobilization weight was not less than contralateral side. Group 1 lost 20-30% within 20 days; thereafter, muscle weight was constant. Maximal isometric twitch tension - the ability to develop active tension of tibialis anterior muscle fixed at the relaxed position was preserved better than that of muscle fixed at the other position. Hypertrophy was observed on the tibialis anterior fixed at the extended position within 30 days. Calf muscle fixed at extended position was relatively more resistant against loss of tension development than muscle fixed at relaxed position.

SOURCE: Nagoya Medical Journal 10(3-4): 105-118, 1964

AUTHOR(S): Kawakami, M., H. Negoro and E. Terasawa

EXPERIMENT TITLE: Influence of Immobilization Stress Upon the Paradoxical Sleep (EEG Afterreaction) in the Rabbit

SUBJECTS: 45 Mature (2.8-3.5 kg), 7 immature (0.6-0.8 kg) female New Zealand rabbits

AREA OF STUDY: Endocrine; Nervous

OBJECTIVES: In title

PROTOCOL: Nine groups: 1) insomnia for 12 hr; 2) insomnia for 24 hr; 3) immobilized mature rabbit for 6 hr; 4) immobilized immature rabbit for 6 hr; 5) immobilized for 6 hr, administered hydrocortisone in the anterior median eminence, supraoptic region and ventromedial hypothalamus of the brain; 6) immobilized for 6 hr, previously receiving bilateral lesions in the hypothalamus; 7) administration of ACTH; 8) administration of DOC; 9) administration of insulin. Adults were ovariectomized. All animals had electrodes placed in various places in the brain, especially the hypothalamus, and EEGs were recorded. Measurements: effects of the above on the electroencephalogram episodes of "paradoxical sleep" or "EEG afterreaction."

IMMOBILIZATION METHOD: Fixed to a table in supine position

RESULTS: After 12 hr insomnia, the paradoxical sleep (PS) episode was greatly heightened in the first 4 hr. It took longer to develop PS episode after 24 hr insomnia. Immobilization caused a complete block of PS episode during the first 4 hr of release. Lesion of the hypothalamus prior to immobilization removed the PS episode block completely, and PS episodes reached 3 to 4.5 times that of those without lesion. Hydrocortisone plus immobilization allowed the PS episode to appear for only 3 to 12 min, but the blocking effect of restraint was removed only when hydrocortisone was administered to the median eminence, ventromedial hypothalamus, and supraoptic region. ACTH completely blocked PS episodes. DOC had no inhibitory effects. Insulin blocked PS episodes for 85-101 min after injection.

SOURCE: Japanese Journal of Physiology 15: 1-16, 1965

AUTHOR(S): Kawakami, M., K. Seto, and F. Kimura

EXPERIMENT TITLE: Influence of Repeated Immobilization Stress Upon
the Circadian Rhythmicity of Adrenocorticoid
Biosynthesis

SUBJECTS: 170 Female New Zealand white rabbits (2.5-3 kg)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Prestress: rabbits were maintained in a controlled light-dark environment. Immobilization stress: 6 hr daily for 7-day period. Groups of 10 rabbits each were decapitated at 3-hr intervals and the adrenal glands quickly removed. Diet: artificial; water ad libitum. Measurements: incorporation of ^{14}C -l-acetate into corticosterone and 17-hydroxycorticosterone in their adrenal homogenates.

IMMOBILIZATION METHOD: Not stated

RESULTS: A diurnal rhythm was seen in the activity of adrenocorticoid biosynthesis in nonstressed rabbits, with a maximum at 18.00 hr and a minimum at midnight; in immobilized rabbits the activity showed an 80% increase at 3 hr and a 40% increase at 6 hr with the lowest level seen 9 hr postimmobilization. The 7th immobilization did not affect the diurnal rhythmicity of adrenal biosynthetic activity or induce its facilitation.

SOURCE: Neuroendocrinology 9: 207-214, 1972

AUTHOR(S): Kazarian, L.E. and H.E. Von Gierke

EXPERIMENT TITLE: Bone Loss as a Result of Immobilization and Chelation:
Preliminary Results in Macaca mulatta

SUBJECTS: Male rhesus monkeys (7-10 kg)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Experiment 1 - Immobilization: Full body plaster cast was applied under anaesthesia to 16 experimental subjects (16 control subjects). All animals were hand fed twice daily, distilled water available to them at regular intervals. At 2 wk intervals they were anesthetized, removed from their casts, weighed, radiographed and examined. The animals were killed after the 60-day period. Experiment 2 - Chemical Removal of Calcium; 12 monkeys: A 0.4% solution of Na_2EDTA diluted with 250 ml of 0.9% sodium chloride solution was infused iv every Monday, Wednesday and Friday for 3 mo; 4-5 hr were required for a 125 ml infusion. Routine A-P and lateral whole-body radiographs and urine samples were taken weekly. At predetermined periods, the experimental and control animals were killed with an overdose of pentobarbital. A complete necropsy was performed and representative tissue samples of all organ systems were prepared for histopathologic examination.

IMMOBILIZATION METHOD: Plaster of Paris cast

RESULTS: Experiment 1: Immobilization resulted in thinning of the trabecular structure and a considerable loss of bone strength with respect to axial compressive loading of individual vertebral bodies. There was an overall diffuse increase in radiographic translucency, increased bone resorption in the metaphysis of the axially-loaded long bones and loss of cortical bone. Remodeling was most active in regions where stresses were transferred from one bone to another. The deformation of the demineralized vertebral segment was greater than that of the control primates. Experiment 2: Infusion of Na_2EDTA resulted in expected hypercalcinuria. Uniform irregularities in the trabecular structures with some accentuation of primary trabecular patterns was accompanied by minor atrophy of interconnecting horizontal members. No measurable difference in cortical thickness of vertebrae were observed. Points of ligamentous attachments did not undergo the resorption seen in the specimens from the immobilization experiments. There was loss of cortical thickness and marked thinning of the femoral shaft with continued EDTA administration. Compression tests of fresh femora showed a severe decrease in bone strength compared with fresh normal femora.

SOURCE: Clinical Orthopaedics and Related Research 65: 67-75, 1969

AUTHOR(S): Kazarian, L.E. and H.E. Von Gierke

EXPERIMENT TITLE: Disuse Atrophy in Macaca mulatta and Its Implications for Extended Spaceflight

SUBJECTS: 40 Male rhesus (Macaca mulatta) monkeys (7-10 kg)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Control and experimental monkeys were placed in metabolic cages for 7 days. After 7 days of conditioning, all monkeys were anesthetized with 1 cc/2.25 kg pentobarbital and radiographed. While under anesthesia, full body plaster of Paris casts were applied to the experimental animals for 60 days. At 2-wk intervals, monkeys were anesthetized, removed from the casts, weighed, radiographed, and examined for complications. Three experiments: 1) 6 experimental and 6 control animals were killed with an overdose of pentobarbital and a complete necropsy was performed; 2) 7 experimental and 7 control animals were subjected to longitudinal spinal impact at predetermined acceleration levels. After impact exposure, the animals were killed with an overdose of pentobarbital and a complete necropsy was performed; 3) 7 experimental and 7 control animals were subjected to longitudinal spinal impact. They were then examined and returned to postimmobilization cages. Spinal radiographs were taken at monthly intervals. At the end of 7 mo, the animals were killed with an overdose of pentobarbital and a complete necropsy was performed. Diet: standard monkey chow. Measurements: food intake; thoracic and lumbar vertebrae.

IMMOBILIZATION METHOD: Plaster of Paris full-body cast

RESULTS: For Experiment 1, macrophotographs showed a marked difference in the vertebral bodies' architecture. Macrophotographs of normal and casted dry bone segments showed a reduction in size and number of trabeculae, along with a decrease in plate size, orientation, and porosity. For Experiment 2, the G level required to produce an average 20% loss of vertebral body height in casted monkeys was about 30% less than in controls. Necropsy showed the mechanism of energy dissipation within the vertebral bodies was to drive the viscous hematopoietic tissue out of the paravertebral sinuses and under the surrounding ligamentous structures. There were no fractures in the controls, but there was vertebral body collapse in casted monkeys, and protrusion of intervertebral disk substance into the adjacent vertebral body through minute stellate tears in the central portion of the adjacent cartilaginous end plate. For Experiment 3, initial radiographs showed no indication of major vertebral body trauma. At the end of 3 mo, lateral radiographs showed a multiple discontinuity in the contour of the cartilaginous plate in 5 of 7 casted monkeys. Subsequent serial radiographs showed gradual development of disk herniation; after 7 mo there were bony barriers surrounding the semisolid nucleus pulposus.

SOURCE: Hypogravic and Hypodynamic Environments, Proceedings of a Conference, French Lick, Indiana, June 16-18, 1969 (ed. by R.H. Murray and M. McCally), Washington, D.C., National Aeronautics and Space Administration, 1971, pp. 129-144. (NASA SP-269)

AUTHOR(S): Keim, K.L. and E.B. Sigg

EXPERIMENT TITLE: Physiological and Biochemical Concomitants of Restraint Stress in Rats

SUBJECTS: Male Sprague-Dawley rats, Hooded, Fisher, Wistar and Spontaneously Hypertensive rats (295 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Seven groups: 1) controls; 2) restrained for 1, 2, 3, 4 or 18 hr, animals decapitated at end of restraint; 3) restrained for 4 hr, temperature and blood pressure taken at 15, 30, 60, 120 and 240 min intervals; 4) restrained 30 min/day for 1, 2, 3, 4 and 5 days, then immediately killed; 5) restrained for 30 min/day for 1, 2, 3, 4 and 5 days, allowed to recover for 30 min then killed; 6) electroshocked for 2 sec every 88 sec with a 2 mA current for $\frac{1}{2}$, 1, 2 and 4 hr; 7) placed in a novel environment consisting of a small, translucent plastic box. After decapitation, trunk blood was collected, adrenals and brain were excised. After 18 hr restraint, the heart was examined histologically. Some Sprague-Dawley rats were made hypertensive by nephrectomy and administration of DOCA before testing. Measurements: body temperature, blood pressure, body movements, corticosterone (CS) levels, norepinephrine (NE) levels, dopamine (DA) levels, epinephrine (EPI) levels.

IMMOBILIZATION METHOD: Plexiglas cylinder (7 cm diameter)

RESULTS: Restraint of 30 min duration increased plasma CS and lowered hypothalamic NE. Restraints of longer durations attenuated those changes. Daily repetitive restraint enhanced the CS response on the 2nd day and progressively diminished it on subsequent days. Whole brain NE increased on the 1st day and decreased on days 2-5. The CS response to acute restraint was similar in 5 different normotensive rat strains, but was enhanced in the genetically hypertensive SH rat, its normotensive backbreed WKY, and the DOCA hypertensive Sprague-Dawley. Comparison with electric foot shock and novel environment indicated that restraint responses differed in time course, if not quantitatively.

SOURCE: Pharmacology Biochemistry and Behavior 4: 289-297, 1976

AUTHOR(S): Keizer, H.J. and L.M. van Putten

EXPERIMENT TITLE: The Radioprotective Action on Bone Marrow CFU during Immobilization of Mice

SUBJECTS: Mice, CBA X C57BL-F1

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Eleven groups of 20 mice each: 1) anesthetized 10 min before whole body irradiation of 500-1500 rad; 2) nonanesthetized irradiated control; 3) anesthetized 10 min before irradiation - 3 dose levels; 4) immobilized by restraining legs with rubber bands - 3 dose levels of irradiation; 5) unanesthetized, unrestrained irradiated controls; 6) anesthetized 10 min before 175 rad whole body irradiation; 7) radiation only controls; 8) Ro-07-0582 (.01 ml/gm) ip 1 hr before whole body radiation, mice killed 5 min before radiation; 9) controls injected with saline; 10) Ro-07-0582 ip treatment of anesthetized and 11) restrained animals. Measurements: mortality, femur bone marrow cell survival by CFU assay.

IMMOBILIZATION METHOD: Rubber bands around the legs

RESULTS: Anesthesia and restraint without anesthesia during whole-body x-irradiation decreased the mortality from both the bone marrow and the intestinal syndromes. The two types of immobilization decreased the radiosensitivity of the hemopoietic stem cells, as shown by an increased survival of hemopoietic stem cells in the marrow of immobilized mice. The hypoxic cell radiosensitizer Ro-07-0582 reversed the radioprotective effect during pentobarbital anesthesia. Pentobarbital inhibited the recruitment of resting femur bone marrow stem cells into cycle following a sublethal dose of x-rays.

SOURCE: Radiation Research 66: 326-336, 1976

AUTHOR(S): Kemp, C.R., W.W. Tuttle, and H.M. Hines

EXPERIMENT TITLE: Studies on the Temperature Characteristics, Blood Flow and Activity in Normal and Denervated Limbs of the Dog

SUBJECTS: Adult dogs

AREA OF STUDY: Circulatory; Muscular

OBJECTIVES: In title

PROTOCOL: Denervation was accomplished by sectioning the sciatic nerve at the level of the trochanter and by cutting the femoral nerve just below the ligament of Poupart. The unoperated contralateral limb served as a control. The efficiency of the temperature regulating mechanism in denervated limbs was compared to that in normal limbs. In order to compare the effect of application of heat to normal and denervated muscle, short-wave diathermy was applied to both the control and denervated gastrocnemii of 29 animals. Studies were also carried out to determine the contraction and relaxation times of the gastrocnemius muscle. Measurements: temperatures in the denervated gastrocnemii; blood flow.

IMMOBILIZATION METHOD: Denervation

RESULTS: Denervation was followed by an immediate increase in blood flow through the femoral artery, the flow returning to normal after several days of denervation. Denervated muscles exhibited a subnormal temperature and responded to diathermy with temperature increases greater than those observed in normal muscle. The twitch response of denervated muscle to induction shocks was slower than that of control muscle.

SOURCE: American Journal of Physiology 150: 705-711, 1947

AUTHOR(S): Kharmosh, O. and P.D. Saville

EXPERIMENT TITLE: The Effect of Motor Denervation on Muscle and Bone in the Rabbits Hind Limb

SUBJECTS: Male Chinchilla rabbits, 4 mo old (2 kg)

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Unilateral motor denervation of hind limbs performed via hemilaminectomy; rabbits sacrificed in 4 groups at 10 days, 4-6 wk, 8-10 wk and 12-14 wk. Twenty-four hr before sacrifice, each rabbit was injected iv with about 5 microcuries of Ca-47 as CaCl_2 . Diet: Ralston Purina pellets enriched with vitamins A and D. Measurements: muscle weight; volume/density of bone; ash weight; radioactivity in bone ash.

IMMOBILIZATION METHOD: Denervation

RESULTS: Significant muscle atrophy was evident by the 10th day post-operatively and progressed steadily until the 10th wk, when the weight of the muscles on the paralyzed side averaged 55% of the control. Bone atrophy showed the same trend as muscle atrophy but was less pronounced. Bone ash weight averaged 90% of control side at 10 days, 86% at 4-6 wk, 72% at 8-10 wk, with no significant difference at 12-14 wk. As the amount of ash decreased so did the total radioactivity.

SOURCE: Acta Orthopaedica Scandinavica 36: 361-370, 1965

AUTHOR(S): Khechninashvili, G.G.

EXPERIMENT TITLE: Role of Adrenals in the Mobilization of Carbohydrate and Fat Resources After Overstimulation of Rats

SUBJECTS: 350 Male rats (180-200 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Immobilization period: 10 min, 30 min, - 1 and 3 hr, followed by decapitation. One month before immobilization, the cerebral layer of the adrenal gland was removed. Adrenalectomy was performed 36-48 hr preexperiment. The animals were immobilized by fixing them in a stand. Some animals received 2.5 mg/kg DOCA im and 25 mg/k dexamethasone intraabdominally before adrenalectomy. Measurements: concentration of 11-hydroxy corticosteroids (11-HXC), free fatty acids and glucose in blood plasma, and liver glycogen.

IMMOBILIZATION METHOD: Fixation in a stand

RESULTS: Suppression of the hyperglycemic reaction to immobilization was observed in the adrenalectomized and adrenomedullized animals. An increase in plasma 11-HXC was observed at 10 min of immobilization which peaked at 30 min. The sharply increased free fatty acid levels of immobilized animals were not significantly altered by adrenomedullation or adrenalectomy with or without hormone support.

SOURCE: Farmakologiya i Toksikologiya 35(5): 575-580, 1972

AUTHOR(S): Kholkute, S.D. and K.N. Udupa

EXPERIMENT TITLE: Effect of Immobilization Stress on Implantation and Pregnancy in Rat

SUBJECTS: Adult female rats

AREA OF STUDY: Reproductive

OBJECTIVES: In title

PROTOCOL: Immobilization: 8 per group, 120 min per day, subjects were immobilized in a prone position on a specially designed board by fastening their limbs to 4 metal strips with adhesive tape. Prior to stress, the stage of the estrus cycle was identified microscopically; females in proestrus were left overnight with fertile male rats, and animals showing clumps of spermatozoa in the smears (day 1 of pregnancy) were selected for the immobilization. Groups: immobilized from day 1 to day 5 of pregnancy; day 3 only; day 3 to day 5; day 12 to day 15; controls. On day 10 of pregnancy all the animals were laparatomized. Measurements: number of implantation sites in utero and corpora lutea in ovaries; number of pups - examination for gross defects.

IMMOBILIZATION METHOD: Board with metal strips and adhesive tape

RESULTS: No implantation was observed in 37.5% of the animals immobilized from day 1 to day 5 of pregnancy. A significant reduction in the number of implantation sites in utero was observed; 2 failed to deliver. Similarly, from day 3 to day 5 a reduction in the number of implantation sites was observed; 2 showing implantation failed to deliver. No significant effect was observed when stress was produced on day 3 of pregnancy. When the stress was induced from day 12 to day 15 of pregnancy, a significant reduction in the number of implantation sites versus litter size was observed, and 50% of animals showing implantation failed to deliver. The litters delivered appeared normal but were reduced in weight.

SOURCE: Indian Journal of Experimental Biology 16: 799-800, 1978

AUTHOR(S): Khruleva, L.N.

EXPERIMENT TITLE: Effect of Hypokinesia on Conditioned Reflex Activity of White Rats

SUBJECTS: 27 White rats

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 9 controls; 2) 18 rats, restrained in special frames for 30 days. The rats were trained over 3½ mo to a motor-food procuring conditioned reflex to 2 differentiated tones. The rats were immobilized, and the conditioned reflexes were tested on days 6, 16, 23 and 30 by removal to a test cage for 5-6 min; temperature and weight were also taken at this time. Their weight, general condition and reflex activity were tested during 30 days of recovery. Diet: ordinary.

IMMOBILIZATION METHOD: Special frame

RESULTS: After 6 days restraint, there was an average weight loss of 52 gm; conditioned reflex activity was depressed. After 16 and 23 days, the rats had started to regain weight (24-33 gm), had excessive hair loss, and an even greater reflex depression in comparison to controls. On the 30th day, their general condition had stabilized but the conditioned reflex had degraded further; even to the point of disappearance. The latent periods of the conditioned reflex had increased almost fourfold from initial testing. Recovery of the conditioned reflexes began on the 3rd-8th day and was complete by the 16th-20th day.

SOURCE: Space Biology and Medicine 3(6): 116-118, 1969

AUTHOR(S): Kim, Y.S., R. Kerr, and M. Lipkin

EXPERIMENT TITLE: Cell Proliferation During the Development of Stress Erosions in Mouse Stomach

SUBJECTS: 26 Male CFW mice (25-30 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two Series: I - 2 groups: 1) controls; 2) mice were deprived of food and water and restrained for 12 hr in a wire mesh cylinder. At intervals of 1-3 hr, 2 mice, 1 under stress (restrained) and 1 control, were injected with tritiated thymidine. All animals were killed 1 hr after injection, so the first mouse killed in the experimental group had been under stress for 13 hr and the last for 42 hr. Stomachs were excised, examined, sectioned through the mid portion of the gastric body and micro-autoradiographs were made. Series II - The experiment was repeated using an injection of tritiated L-leucine-4,5. Measurements: changes in ultra-structure of stomach cells, counts of mitoses and labelled cells.

IMMOBILIZATION METHOD: Wire mesh cylinder

RESULTS: Series I: Histological examination of the gastric mucosa of restrained mice revealed scattered focal areas containing moderate vacuolization of cytoplasm in epithelial cells and slight to moderate decrease in PAS-positive mucopolysaccharide. Desquamation of surface cells was increased and some early collapse of the mucosa was seen. There was no edema, inflammatory exudate or necrosis. The stressed mice had significantly reduced mitoses and reductions in labelled cells. Series II: Active incorporation of leucine into all cell types was seen throughout the mucosa, epithelial cells showing histological abnormalities were well labelled with leucine.

SOURCE: Nature 215: 1180-1181, 1967

AUTHOR(S): Kirichek, L.T. and V.I. Zholudeva

EXPERIMENT TITLE: Morphological and Functional Manifestations of Rat Adrenal-Cortex Response to Sodium Bromide Administration Under Hypodynamic Stress

SUBJECTS: 132 Albino rats (100-150 gm)

AREA OF STUDY: Endocrine; Pharmacology

OBJECTIVES: In title

PROTOCOL: Three groups: 1) immobilization and sodium bromide - 2 hr immobilization on an operating table, sodium bromide administered in 100, 250 and 500 mg/kg doses once or repeatedly for 10 days. Studies were made at different times within 1, 2, 3 and 4 hr after single administration and at the end of the 10 day experiment; 2) sodium bromide only, intact animals; and 3) controls. Measurements: ascorbic acid; cholesterol; morphological evaluation of the adrenal.

IMMOBILIZATION METHOD: Operating table

RESULTS: The administration of bromine to intact animals weakened the functional state of the adrenal cortex; there was an increase in the content of ascorbic acid and a reduction in the cholesterol level. No significant morphological differences were found between the adrenal cortex glands of the intact and control animals, under doses of 100 and 250 mg/kg. An increase in the dose to 500 mg/kg in these conditions led to the appearance of pronounced vascular and dystrophic changes. At the end of 10 days a considerably greater loss of fat and lipids was noted. Two hr immobilization of rats resulted in attenuation of the functional state of the adrenal cortex; ascorbic acid increased; cholesterol and its esters was reduced. The morphological picture of the adrenal cortex still reflected its active state. The single and repeated administration of sodium bromide that preceded the hypodynamic stress restored the content of ascorbic acid in the adrenal cortex of rats. The content of cholesterol in the adrenal glands with single administration of sodium bromide progressively dropped, and with repeated administration reached the initial figures.

SOURCE: Farmakologiya i Toksikologiya 38(6): 703-706, 1975

AUTHOR(S): Kirilyuk, O.G. and Yu.V. Khmelevskiy

EXPERIMENT TITLE: Absorption of Thiamine and Nicotinic Acid in the Rat Intestine During Fasting and Immobilization Stress

SUBJECTS: 50 White male rats (200 ± 20 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls; 2) immobilized horizontally on a board for 24 hr; 3) fasted for 72 hr. The absorption of thiamine was studied by perfusing a piece of the small intestine with a sodium chloride solution with thiamine at a concentration of $3.1 \mu\text{M}$. Thiamine absorption was determined by the decrease in thiamine in the perfusate. The nicotinic acid absorption was determined from the degree of disappearance of the ^{14}C label in nicotinic acid administered to a piece of the small intestine at a concentration of $40 \mu\text{M}$. The $\text{Na}^+\text{-K}^+\text{-ATPase}$ activity was determined.

IMMOBILIZATION METHOD: Board

RESULTS: Thiamine absorption in animals fasted for 72 hr decreased by 28%; absorption increased by 12% in the immobilized rats. After immobilization, absorption of labelled nicotinic acid increased as well as the $\text{Na}^+\text{-K}^+\text{-ATPase}$ activity. $\text{Na}^+\text{-K}^+\text{-ATPase}$ activity in the intestinal mucosa decreased by 10% during fasting.

SOURCE: Fiziologichnyi Zhurnal 23(1): 98-102, 1977

AUTHOR(S): Klimovskaya, L.D. and N.P. Smirnova

EXPERIMENT TITLE: Peculiarities of Reaction of the Rat Cerebellum to Exposure to Centripetal Accelerations After Prolonged Hypokinesia

SUBJECTS: 90 White rats

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinetic in small cages for periods from 14 to 60 days. Rats from cages and control group were anesthetized and were exposed to transverse acceleration along the back-to-chest axis with 6 G and 10 G for a period of 4 min with a 15 min interval between rotations on a centrifuge with a rotation radius of 4.2 m. A steel needle was introduced into the cortex of a projection zone of the sciatic nerve at the frontal parts of the brain worm. Measurements: cerebellar cortex electrical response to irritation of an extremity nerve; before, during, and after exposure to acceleration, electric responses of the cerebellar cortex to stimulation of the ipsilateral sciatic nerve were measured with an oscillograph from which peak amplitude values were taken.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: After 14 days of hypokinesia, there was an increase in the amplitude of response to irritation of an extremity nerve. At later times, amplitude approached control group indices. Control animals subjected to acceleration exhibited a suppression of the induced potentials of the cerebellum of up to 49% at 6 G, and 32% at 10 G, with gradual restoration after the centrifuge had stopped. After 14 days of hypokinesia, the decrease in induced potentials matched that of the control group. Hypokinetic rats tested on the 35th-40th days showed a marked weakening of reaction of the cerebellum to acceleration exposure. After 55-60 days, there were no significant differences from the control group at 6 G, but at 10 G, there was a prolonged suppression of induced cerebellar activities.

SOURCE: Space Biology and Medicine 8(2): 43-51, 1974

AUTHOR(S): Knott, P.J.

EXPERIMENT TITLE: Effects of Food Deprivation and Immobilization on
Tryptophan and Other Amino Acids in Rat Brain

SUBJECTS: Male Sprague-Dawley rats (180-220 gm)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Rats were either food deprived for 24 hr or immobilized for 3 hr by placing legs through holes in wire grid and adhesive taping front and back pairs of legs together. Measurements: amino acids; tryptophan; 5-hydroxytryptamine (5-HT); 5-hydroxyindoleacetic acid (5-HIAA).

IMMOBILIZATION METHOD: Wire grid and adhesive tape

RESULTS: Food-deprived rats: tryptophan and 5-HIAA increased with only minor changes in 5-HT. Tryptophan ($p < .001$), α -amino-n-butyric acid ($p < .001$), histidine, isoleucine ($p \approx .05$), leucine, lysine ($p \approx .05$), phenylalanine ($p < .05$), threonine, and tyrosine showed changes after deprivation. Immobilization showed nonsignificant changes in histidine, isoleucine, leucine, methionine, phenylalanine, tyrosine, and valine, but a 58% increase ($p < .02$) in tryptophan. Neither condition produced any significant change in plasma total tryptophan.

SOURCE: Journal of Neurochemistry 20: 249-251, 1973

AUTHOR(S): Kogan, A.B., G.I. Sil'chenko, and I.G. Arnautova

EXPERIMENT TITLE: Effect of Long-Term Physical Restriction of an
Animal on Some Body Functions

SUBJECTS: 3 Cats

AREA OF STUDY: Circulatory; Behavior; Nervous

OBJECTIVES: In title

PROTOCOL: Immobilization: 20-30 days in a special immobilizing rig
kept in a soundproof underground room. Diet: ad libitum. Measurements:
ECG; EEG; tracometry.

IMMOBILIZATION METHOD: Connecting halves of casing with openings for
head and paws

RESULTS: The EEG showed a reduction in the mean amplitude of basic
activity waves which was restored after the animals were released.
The waves were reduced when exposed to acoustic irritation (siren).
There was a marked reduction in motor reactions which continued for
1 month after release. After release there was a decrease in
walking rate, stride length, and overall disruption of normal loco-
motion. Various impairments and irregularities in cardiac activity
were observed during and after immobilization.

SOURCE: Space Biology and Medicine 3(1): 80-84, 1969

AUTHOR(S): Kogan, B.I.

EXPERIMENT TITLE: Peculiarities in the Change of Motor Activity of Rats Under Conditions of Hypo- and Hyperdynamia

SUBJECTS: 45 Male August rats; 45 female Wistar rats

AREA OF STUDY: Muscular; Behavior

OBJECTIVES: In title

PROTOCOL: Fifteen rats of each strain were subjected to hypodynamia in a small cage for 2 months, 15 were subjected to hyperdynamia (3-60 min) on a treadmill at 30 m/min and 15 served as a control. Measurements: motor activity, by means of electromagnetic device in each cage.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: After hypodynamia, the motor activity decreased; after hyperdynamia, it increased. In rats of the August line the index of activity after hypodynamia decreased from 58.5 ± 0.9 in the control to 44.4 ± 0.5 movements, whereas in hyperdynamia it increased to 85.3 ± 0.8 movements (in both cases $P < 0.001$). In rats of the Wistar line, kept under the same conditions, the motor activity was 61.3 ± 0.5 movements after hypodynamia, 124.9 ± 1.3 movements in the case of hyperdynamia and in the control was 79.9 ± 1.0 movements ($P < 0.001$ for both hypo- and hyperdynamia). The statistically reliable differences in the motor activity rates of rats of different blood lines detected in controls also persisted in the animals under conditions of hypo- and hyperdynamia.

SOURCE: Space Biology and Medicine 8(6): 133-135, 1974

AUTHOR(S): Kogan, B.I. and Y.S Antipov

EXPERIMENT TITLE: Growth and Formation of the Foreleg Skeleton in
Inbred Mice and Rats Under Conditions of Hypo-,
Normal and Hyperdynamia

SUBJECTS: Inbred 1 mo old male mice (C57B1/6, CBA, CC57Br/Mv, and F1)
and 1 yr old male August and Wistar rats

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Three groups (10 mice and 15 rats each): 1) hypodynamia - animals were placed in small box cages; 2) normal dynamics - animals placed in a vivarium; 3) hyperdynamia - animals were trained to run on a track, 3 min initially and daily increasing the duration by 1 min. Experiment lasted 2 mo. The animals were killed by injection with a needle into the medulla oblongata, after which the bones of the fore left extremities were macerated by chemical means. Diet: standard food ration for all groups. Measurements: osteometry of the scapulae and humeral bone (weight, greatest length and width).

IMMOBILIZATION METHOD: Cage (small box)

RESULTS: Osteometry revealed a direct dependence of weight, longitudinal and transverse dimension on the conditions of maintenance of the animals. With a transition of hypodynamia to normal and hyperdynamia the weight of the studied bones increased in the animals of all lines. Under conditions of limited mobility the weight of the bones was altered considerably greater than under conditions of increased muscle activity. The growth of the scapulae and humeral bones in length was delayed in the hypodynamic and stimulated in the hyperdynamic animals of all lines.

SOURCE: Vestnik Zoologii No.4: 67-71, 1976

AUTHOR(S): Kogan, B.I. and S.I. Lominova

EXPERIMENT TITLE: Effect of Various Types of Rehabilitation on Skeletal Morphology in Inbred Rats After Hypokinesia

SUBJECTS: 160 Inbred August and Wistar rats, 2 mo old

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Five groups: 1) controls; 2) hypokinesia induced by keeping rats in small, close fitting cages. Groups 3-5 were kept under identical hypokinetic conditions, but also received daily rehabilitation methods; 3) running on a treadmill moving at a constant speed of 30 m/min, for 3 min from first hypokinetic day, increased on alternate days by 1 min; 4) as per group 3, but duration of training increased daily by 1 min, for a total of 60 min training by end of experiment; 5) as per group 4, with daily ip injection of amphetamine. The experiment lasted 60 days. Measurements: osteometry; body weight.

IMMOBILIZATION METHOD: Cage (small, close fitting)

RESULTS: Hypokinesia alone produced a significant decrease in body weight. When rehabilitation measures were used the body weight was close to that of control. A similar tendency was observed in the length of the femur and tibia. By contrast with control rats, in animals exposed to hypokinesia ossification was severely disturbed (cancellous substance of the epiphyses had widely-looped structure, bony trabeculae were thin, few osteocytes of reduced size). Adequate development of both the cancellous and compact bone after rehabilitation; almost complete ossification of the proximal epiphyses of the tibia and the distal epiphyses of the femur. After hypokinesia alone, the thickness of the proximal epiphyseal plate of the tibia and the distal epiphyseal plate of the femur were significantly reduced in size. In August rehabilitative rats, the thickness of the epiphyseal plates decreased gradually in groups 3 to 5; in the Wistar rats the maximal effect was seen in group 4. The changes in the compact layer of the femora of the animals receiving rehabilitation measures were in the opposite direction.

SOURCE: Bulletin of Experimental Biology and Medicine 86(7): 947-950, 1978

AUTHOR(S): Kolemeyeva, L.Ya.

EXPERIMENT TITLE: Response of the Animal Body to Central Nervous System Stimulants During Hypokinesia

SUBJECTS: 1,146 White male rats (150-200 gm)

AREA OF STUDY: Pharmacology

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control rats kept in groups; 2) hypokinetic in cages for 60 days. Rats were injected ip with strychnine (2.5-4.5 mg/kg), phenamine (45-85 mg/kg) or caffeine (540-760 mg/kg) on days 1, 5, 10, 15, 30, 45 and 60 of the experiment. Measurements: for strychnine, onset of spasms; for phenamine, onset of "arena" movements; for caffeine, onset of adynamia.

IMMOBILIZATION METHOD: Cage

RESULTS: During hypokinesia there was a decreased response to strychnine and phenamine and an increased response to caffeine.

SOURCE: Aktual'nye Voprosy Kosmicheskoi Biologii i Meditsiny (ed. by O.G. Gazenko et al), Moscow, 1971, pp.127-128

AUTHOR(S): Kolemeyeva, L.Ya. and M.A. Seydametov

EXPERIMENT TITLE: Effect of Narcotics on Animal Body Reactivity During Hypokinesia

SUBJECTS: 1,113 White male rats (150-200 gm)

AREA OF STUDY: Pharmacology

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control rats; 2) rats kept hypokinetic in cages for 1-60 days. Hexanal (360-560 mg/kg), chloral hydrate (520-700 mg/kg) and urethane (1.2-2.0 gm/kg) were injected ip on days 1, 5, 10, 15, 30, 45 and 60 of the experiment. Measurements: LD₅₀ (dose causing death of 50% of the rats) and time to onset of sleep.

IMMOBILIZATION METHOD: Cage

RESULTS: There was an increased reactivity to hexanal on the 1st, 30th and 60th day of hypokinesia and decreased reactivity other times. At all times investigated, there was increased reactivity to chloral hydrate and decreased reactivity to urethane. In hypokinetic rats, narcotic induced sleep occurred later and was less prolonged than in control rats.

SOURCE: Aktual'nye Voprosy Kosmicheskoi Biologii i Meditsiny (ed. by O.G. Gazenko et al), Moscow, 1971, pp.126-127

AUTHOR(S): Kolemeyeva, L.Ya. and V.S. Shashkov

EXPERIMENT TITLE: Sensitivity of the Animal Body to Narcotics During Restricted Motor Activity

SUBJECTS: 1,153 White male rats (150-200 gm)

AREA OF STUDY: Pharmacology

OBJECTIVES: In title

PROTOCOL: Animals restricted in cages for 1, 5, 10, 15, 30, 45 and 60 days. After restricted mobility, animals were anesthetized with chloral hydrate (doses of 520, 560, 600, 660 and 700 mg/kg), hexanal (doses of 360, 400, 440, 480 and 560 mg/kg) and urethane (doses of 1.2, 1.4, 1.6, 1.8 and 2 gm/kg). Both in the absolute control and in the experiment each drug dose was tested on 8 rats. Body sensitivity to the drugs was determined by the time of onset and duration of narcosis.

IMMOBILIZATION METHOD: Cage

RESULTS: The narcosis effect was manifested far more slowly in animals in a state of hypokinesia than in the controls. The duration of maintenance of a narcosis state varied: with administration of chloral hydrate and urethane it was greater and with hexanal administration it was less. Sensitivity to the drugs was dependent on the duration of restricted mobility and the spectrum of the investigated drug.

SOURCE: Space Biology and Aerospace Medicine 8(4): 18-26, 1974

AUTHOR(S): Kolemeyeva, L.Ya., V.S. Shashkov, and B.B. Yegorov

EXPERIMENT TITLE: Radioprotective Effect of Mexamine and Cystamine on the Animal Body Exposed to Hypokinesia and Ionizing Radiation

SUBJECTS: 1,531 Male white rats (200±30 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) restrained for 5, 15, 30 and 60 days in cages; 2) controls. Experimental and control rats were subjected to 800 R general gamma irradiation. 10-15 min preirradiation, radiopreventive substance given ip: 20 mg/kg mexamine and 75 mg/kg cystamine; controls received .9% NaCl. Diet: standard. Measurements: 30 day viability and mean lifetime.

IMMOBILIZATION METHOD: Cage

RESULTS: 5-15 days of hypokinesia did not reduce the effects of mexamine and cystamine under normal motor activity conditions (63-83.7% and 65.1-72.5%, respectively). 30 days of hypokinesia reduced the effect of mexamine 2.5 times and the effect of cystamine 2.2 times; 60 days of hypokinesia reduced the effects 3.5 and 3.6 times, respectively. Beginning on day 15 of preliminary hypokinesia, the average life span of the experimental rats decreased.

SOURCE: Space Biology and Aerospace Medicine 9(6): 124-126, 1975

AUTHOR(S): Kolemeyeva, L.Ya., V.S. Shashkov, and B.B. Yegorov

EXPERIMENT TITLE: Sensitivity of Hypokinetic Animals to Central Nervous System Stimulants

SUBJECTS: White mongrel male rats (200±50 gm)

AREA OF STUDY: Nervous; Pharmacology

OBJECTIVES: In title

PROTOCOL: 1150 rats were divided into experimental and control groups. Experimental rats were restricted in cages for 1, 5, 10, 15, 30, 45 and 60 days. CNS stimulants - caffeine, phenamine, and strychnine - were injected ip after periods of restriction. Changes in the sensitivity of the organism to CNS stimulants were evaluated. Diet: standard.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: Sensitivity to CNS agents was related to both duration of mobility restriction and spectrum of action of the agent tested. With administration of caffeine increases of sensitivity were observed on the 5th, 30th, 45th and 60th days. Later onset of adynamia were also recorded. Phasic changes in sensitivity to phenamine were noted. With administration of strychnine, significant increase in reaction was observed after 5 and 45 days of restricted mobility. Seizures also occurred sooner in experimental animals.

SOURCE: Space Biology and Aerospace Medicine 11(2): 99-105, 1977

AUTHOR(S): Kolpakov, M.G., V.P. Tarasevich, and A.L. Markel

EXPERIMENT TITLE: Effect of Aldosterone on Hemodynamics Under
Conditions of Restricted Motor Activity of Dogs

SUBJECTS: 32 Dogs (12-25 kg) both sexes; ages 2-6 yr

AREA OF STUDY: Endocrine; Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) hypokinetic. After 2 wk of immobilization in close cages, a course of aldosterone administration was initiated in doses of 100 μ g/kg/day for 6 days. Hemodynamics of the experimental animals was investigated under chloralose narcosis 2 times: 2 wk after placement in the cages, after which administration of aldosterone began at once and then 6 days after commencement of aldosterone administration or 3 wk after presence in close cages. Measurements: ECG; curves of dilution; arterial pressure.

IMMOBILIZATION METHOD: Cage (close)

RESULTS: Hypokinesia was accompanied by characteristic shifts in activity of the cardiovascular system which were expressed in a decrease in cardiac minute volume and a decrease in systemic pressure. The cardiotonic effect of aldosterone was associated not only with the transport of electrolytes, but also with the hormonal effect on the energy balance of the myocardial cell.

SOURCE: Space Biology and Medicine 4(2): 69-76, 1970

AUTHOR(S): Konitzer, K. and S. Voigt

EXPERIMENT TITLE: Glucose Metabolism in Different Regions of the Rat Brain Under Hypokinetic Stress Influence

SUBJECTS: Male Wistar rats (150-200 gm)

AREA OF STUDY: Nervous; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Hypokinesia up to 14 wk; rats were shut up for several hr and several times a day in small boxes, with a stochastic alternation of rest periods. Animals were removed from immobilization program at various times and given an injection of ^{14}C D-glucose and ^{131}I serum albumin; 5.5 min later the animal was killed by heat coagulation of the brain with micro-waves. Following decapitation blood samples were taken from the throat vessels, the brain was totally removed from the skull and dissected. Measurements: regional levels of glucose, lactate, glutamate, glutamine, aspartate, γ -aminobutyrate, and the incorporation of ^{14}C from the plasma glucose into these metabolites, in glycogen and protein.

IMMOBILIZATION METHOD: Box (small)

RESULTS: Within the first days of immobilization a functional hypoxia occurred in all brain regions and the utilization of cycle amino acids for protein synthesis was strongly diminished. After the first wk of stress the capillary volumes of all regions increased, aerobic glucose metabolism was enhanced and the incorporation of glucose ^{14}C via cycle amino acids into protein was considerably potentiated. The metabolic parameters normalized between the 7th and 11th wk of stress. Blood supply and metabolic rate increased most in the hypothalamus, reaching the value measured for the cerebral cortex in the initial state.

SOURCE: Acta Biologica et Medica Germanica 35: 853-866, 1976

AUTHOR(S): Konitser, K., Z. Foygt, M. Poppay, and K. Gekht

EXPERIMENT TITLE: Regional Metabolism in the Rat Brain During Stress
Under Hypokinesia

SUBJECTS: Male rats (150-200 gm)

AREA OF STUDY: Nervous; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Hypokinesia (daily multiple and multi-hour immobilization). The animals were given injections of U-¹⁴C-D-glucose and serum of ¹³¹I-albumin and after 5 min, thermocoagulation of the brain tissue was performed. Measurements: changes in the metabolism of glucose in the brain.

IMMOBILIZATION METHOD: Not stated

RESULTS: A delay in the metabolism of glucose during the early stages of protein synthesis was caused by a decrease in the inclusion of C¹⁴.

SOURCE: Zhurnal Vysshei Nervnoi Deitelnosti 27(2): 350-351, 1977

AUTHOR(S): Konkina, N.I.

EXPERIMENT TITLE: Combined Effect of Hypokinesia and Gravitational G-Forces on Wall Structure of the Renal Vein

SUBJECTS: 25 Rabbits

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 6 controls; 2) 19 rabbits hypokinetic for 1 to 8 wk in cages which sharply limited their mobility, after which the animals were exposed to a 9.6 G-force in the head to tail direction for 12 min in a centrifuge of 1 m radius. The animals were killed immediately with ether vapor, and the renal veins of the test and control rabbits were fixed in 12% neutral formalin. Sections were prepared and stained with hematoxylin-eosin and fuchselin for light microscopy examination. Measurements: changes in the wall of the renal vein.

IMMOBILIZATION METHOD: Cage

RESULTS: Hypokinesia for 1 wk, followed by a single application of 9.6 gravitational force caused a slight distention of the middle membrane of the vein. After 3 wk of hypokinesia plus gravitational stress, there was a loosening of the middle vascular sheath with vacuolization of myocytes and outgrowth of its elastic elements. Hypokinesia for 8 wk plus a single gravitational stress produced atrophy of smooth muscle tissue in the middle sheath of the venous wall that decreased the tonus of the wall of the renal vein.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 74(6): 80-84, 1978

AUTHOR(S): Konstantinov, N., L. Cheresharov, S. Toshkova, and K. Lazarova

EXPERIMENT TITLE: Experimental Studies on the Oestrus Cycle in Rats Under the Conditions of Immobilization and Locomotor Activity

SUBJECTS: Female Wistar rats

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Thirty rats were divided into 3 groups of 10 each: 1) functionally loaded rats which were exercised on a treadmill 6 days per week; 2) controls; and 3) physiologically immobilized animals raised separately in single cages with locomotion reduced to a minimum. After 580 days, the animals were killed. Measurements: the phase of the oestrous cycle of each rat was determined by vaginal smears and the number of corpus luteum in the ovary was determined. Diet: standard pelleted mixture.

IMMOBILIZATION METHOD: Cage

RESULTS: In the immobilized animals, hypoplastic changes in the ovary were found (less number of corpus luteum). Also observed were a strongly expressed atresia of the follicles, leading to increasing interstitium and strongly dilated blood vessels. The quality of fibrous tissue was increased in the central part of the ovary. Disturbances in metabolism and hormonal activity of the tissues were found. Histochemical studies showed greater quantities of cholesterol and neutral fats during the longer periods of the oestral cycle and considerably diminished content of polysaccharide and phospholipids in the ovaries of the immobilized animals.

SOURCE: Aggressologie 18(6): 307-317, 1977

AUTHOR(S): Kopteva, L.A., V.I. Biryuzova and E.B. Shul'zhenko

EXPERIMENT TITLE: Biochemical and Electron-Microscopic Characteristics of Mitochondria of the Dog's Heart in Hypokinesia

SUBJECTS: 12 Dogs (15-18 kg)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinesia. Hypokinesia was produced by secure fixation by application of soft splints, or plaster of Paris slabs and bandages under morphine anesthesia. After 15 days, thoracotomy was performed and the heart quickly extracted. Ventricular mitochondria was subjected to biochemical and electron-microscopic investigation.

IMMOBILIZATION METHOD: Soft splints; Plaster of Paris slabs and bandages

RESULTS: Immobilization led to a 27-30% decrease in the absolute weight of the heart. A marked decrease in mitochondria was found in both ventricles. The concentration of high polymer RNA in mitochondria from myocardium of the left ventricle was reduced by 50.8% and in the mitochondria of the right ventricle by 27.5%. There was also a decrease in the ability of the mitochondria to incorporate C^{14} -labeled amino acids. Electron-microscopic investigation of the ventricular mitochondria after hypokinesia for 15 days revealed slight damage to mitochondria of general type, while mitochondria of muscular type were well preserved.

SOURCE: Bulletin of Experimental Biology and Medicine 70(8): 866-868, 1970

AUTHOR(S): Korol'kov, V.I., Ye.A. Kovalenko, V.P. Krotov, N.A. Ilyushko,
V.A. Kondrat'yeva and Yu.I. Kondrat'yev

EXPERIMENT TITLE: Mechanisms of Water-Salt Metabolism Disturbances in
Dogs Subjected to Six-Month Hypokinesia

SUBJECTS: 12 Male dogs (6-9 kg)

AREA OF STUDY: Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: The motor activity of the dogs was restricted for 6 mo by placing them in special devices that permitted the animal to adopt the positions "lying down", "sitting" and "standing". Measurements: quantity of consumed food and the water content in it; quantity of released excrement and urine; content of potassium, sodium, calcium and magnesium in the food, excrement and urine; total water in the body; volume of extracellular fluid; volume of circulating plasma; volume of circulating blood; volume of erythrocyte mass.

IMMOBILIZATION METHOD: Device which permitted lying down, sitting and standing

RESULTS: Prolonged hypokinesia caused pronounced and distinct changes in the hydration status of the animals with a redistribution of the fluid between its different sectors. Despite the preservation under conditions of hypokinesia of the support function of the skeleton, the reduction in motor activity resulted in the emergence of explicit disorder in the state of salt metabolism. Especially sharp changes were noted in the metabolism of magnesium and calcium; the magnesium balance approached zero, while calcium became negative.

SOURCE: Patologicheskaya Fiziologiya i Eksperimentalnaya Terapiya
No.6: 32-35, 1977

AUTHOR(S): Kosourov, A.K.

EXPERIMENT TITLE: The Morphology of the Walls of Certain Major Arteries
in the Norm and During Limitation of Motor Activity

SUBJECTS: 66 Rabbits (2.5-3 kg)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) hypokinesia, 56 rabbits were placed in small cages, and were killed with ether vapor after 1, 2, 3, 4, 6, 8 and 12 wk; 2) 10 controls. The tissue specimens for preparing slides were taken in the proximal and distal vascular regions, always at precisely the same level, and were fixed in 12% neutral formalin. Measurements: histological study of the major arteries - aorta, carotid, brachial and femoral and the microcirculatory bed of the aorta adventitia.

IMMOBILIZATION METHOD: Cage

RESULTS: The structure of the walls of major arteries did not differ significantly from that in control animals in the early terms, 1-2 wk. Pronounced morphological changes in the vascular wall structure appeared after 4 to 6 wk of hypokinesia. In the carotid arteries, the integrity of the elastic body was disturbed in the form of a break of some elastic membranes. Vessels of the muscular type - brachial and femoral - suffered the most. Their walls experienced rapid growth of elastic fibers which transformed the vessel into an elastic type vessel, and atrophy of the vessel wall developed. Additional changes occurred in all components of the microcirculatory bed of the aortal adventitia observed mostly in the capillary-venulas links of the bed. With increased hypokinesia duration homeostasis was observed in capillaries and venulas, and their diameters increased with a simultaneous decrease in arteriole diameter.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 69(10): 40-44, 1975

AUTHOR(S): Kosourov, A.K.

EXPERIMENT TITLE: The Structure of the Wall of Main Arteries in Response to Hypergravitation and Hypokinesia in Experiments

SUBJECTS: 260 Rabbits (2.5-3 kg)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Seven groups: 1) controls; 2) exposed to a 9.6 G-force for 25 min; 3) exposed to a 9.6 G-force for 25 min, after previously undergoing a conditioning schedule of increasing G-forces; 4) hypokinesia in "special containers" for 1-12 wk; 5) hypokinesia for 1 mo, allowed to recover for 12 wk; 6) hypokinesia for 1-12 wk, then subjected to a 9.6 G-force for 15 min; 7) subjected to conditioning schedule of increasing G-forces, a single prolonged 9.6 G-force, 4 wk of hypokinesia, and a repeated exposure to 9.6 G-force. Rabbits were killed with ether vapor; carotid, humeral, aorta and femoral arteries were removed, fixed, stained and examined by microscopy. Measurements: changes in the structure of the arterial walls.

IMMOBILIZATION METHOD: Container (special narrow)

RESULTS: A single exposure to 9.6 G-force caused insignificant changes in the main artery walls. The microcirculatory bed of the aortic adventitia suffered congestive hemostasis, and an increase in twisting and dilation of the microvessels. The conditioned group withstood the G-forces much better. Hypokinesia caused a development of hyperelastosis after 2 wk, and with increased time, atrophy, fragmentation and degeneration. The muscle tissue in the humeral and femoral arteries was almost completely replaced by elastic tissue. The microcirculatory bed of the aorta underwent congestion and diapedesic hemorrhage. In group 5, animals did not begin to recover from 1 mo of hypokinesia until the 4th wk. The walls of muscle-type arteries were restored in 2-3 wk. The aorta did not recover till the 8-12 wk. In group 6, the tolerance to G-forces decreased from 13.7 min after 1 wk hypokinesia, to 9.8 min after 12 wk of hypokinesia. At the end of group 7 experiments, the tolerance of the 9.6 G-force decreased from the control level at 15 min to 9.48 min. G-forces and hypokinesia caused similar changes in the arteries studied.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 70(6): 47-54, 1976

AUTHOR(S): Kovalenko, Ye.A., V.L. Popkov, Yu.I. Kondrat'ev, E.S. Mailyan, Yu.S. Galushko, A.A. Prokhonchukov, V.A. Kazaryan, R.S. Morozova, L.V. Serova, A.N. Potapov, V.S. Romanov, and V.B. Pishchik

EXPERIMENT TITLE: Changes of the Body Functions During Long-Term Hypokinesia

SUBJECTS: 2000 Rats (200-250 gm)

AREA OF STUDY: Metabolism and Energy Exchange; Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats were placed in special locking cages made of plexiglas in which their mobility was sharply limited for 60 and 100 days. Diet: 91 kcal per day. Measurements: total gas exchange; tissue breathing and oxidative phosphorylation; the inclusion of phosphorus (P-32), calcium (Ca-45) and glycine (2C-14) in the bones and teeth; Ca, Na and Cl in the urine; resistance of muscle tissue; corticosterone in the blood and adrenals; plasma ACTH; the reaction of the adrenal cortex and increase in content of ACTH of the blood.

IMMOBILIZATION METHOD: Cage (plexiglas)

RESULTS: Prolonged hypokinesia provoked considerable changes in the gaseous and energetic metabolism: an elevation of the total gaseous metabolism and of the rate of O₂ requirement by the muscles (in the late periods of hypokinesis), and in the intensity of tissue respiration of the liver and myocardium. There proved to be a reduction in the level of phosphorylation and separation of oxidative phosphorylation in the myocardium, liver, and partially in the skeletal muscle. Prolonged hypokinesia led to considerable changes in tissue metabolism: a disturbance of development of the animals, a marked delay and an increase in the weight of the organism and the muscular system, and disturbances of the mineral and protein metabolism. Prolonged hypokinesia led to exhaustion of the hypothalamus-hypophysis-adrenal cortex system.

SOURCE: Patologicheskaya Fiziologiya i Eksperimentalnaya Terapiya
No.6: 3-9, 1970

AUTHOR(S): Kovalenko, Ye.A., V.L. Popkov, E.S. Mailyan, Yu.S. Galushko, N.V. Gordeycheva, Yu.I. Kondrat'yev, N.A. Ilyushko, A.N. Poptapov, L.N. Grinberg, and M.A. Seydametov

EXPERIMENT TITLE: Effect of Hypodynamia on Gas Exchange in Animals

SUBJECTS: 29 Dogs (6-8 kg); 2000 White rats (173-183 gm)

AREA OF STUDY: Respiratory; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 29 dogs, 60 days in special restraints which only allowed the animals to get up and sit down; 2) 2000 rats, 100 and 120 days in special plexiglas restraint cages. Diet: 91 Cal per day (rats). Measurements: gas exchange; gas homeostasis in subcutaneous cellular tissue and adjacent muscle tissue; rate of in-vivo oxygen consumption in muscle; tissue respiration and oxidative phosphorylation in the skeletal muscles, myocardium, brain and liver; oxidative processes in liver mitochondria; body weight.

IMMOBILIZATION METHOD: Cage (plexiglas); Special restraint

RESULTS: Dogs exhibited a distinct decrease in O_2 consumption and a decrease in CO_2 elimination by the end of the 1st month, and some increase by the end of the 2nd month. By the 7th day following the experiment O_2 consumption returned to normal levels. Rats exposed to a longer hypokinesia exhibited no noticeable changes in total gas exchange at early stages of the experiment and a distinct acceleration of gas exchange and regional oxygen consumption in muscles by the 90th-100th day. No significant changes were found in gas pressure in the tissues and their dynamics. In vivo O_2 consumption by the 90th-100th day increased. Tissue respiration from the 30th to 60th day changed in individual organs/tissues: increase in intensity of renal tissue respiration; decrease in myocardium. There were no significant changes in the relationship between free and phosphorylating oxidation in the body; individual tissues - some decrease in the P/O coefficient in heart, liver and muscle tissue. There was a distinct decrease in the response of liver mitochondria to the addition of ADP from the outside. Immobilized animals increased in weight by an average of 7 gm over 100 days.

SOURCE: Space Biology and Medicine 5(4): 1-8, 1971

AUTHOR(S): Kovalenko, Ye.A., Yu.S. Galushko, S.G. Sherashov, and
V.L. Popkov

EXPERIMENT TITLE: Physical Performance and Oxygen Supply of the Rat
Body During Physical Loads After Prolonged Hypokinesia

SUBJECTS: White rats (190-200 gm)

AREA OF STUDY: Respiratory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 62 controls; 2) hypokinesia, 90 rats were placed in special cages where they were kept in a fixed pose. Swimming and static tests were carried out for evaluating the physical performance of rats on the 60th and 100th days of hypokinesia and also on the 30th and 60th days of the recovery period. Gas exchange during swimming was investigated in order to judge oxygen balance of the animals.

IMMOBILIZATION METHOD: Cage

RESULTS: The rats exhibited a substantial and progressive decline in tolerance to a maximum physical load during hypokinesia. This was accompanied by disorders in the regulation of the oxygen balance.

SOURCE: Space Biology and Medicine 9(1): 19-29, 1975

AUTHOR(S): Kovalenko, Ye.A., E.S. Mailyan, V.L. Popkov, Yu.S. Galushko, A.A. Prokhonchukov, Z.S. Dopgun, Yu.I. Kondrat'yev, M.I. Kozar', G.P. Tikhonova, A.G. Kolesnik, V.A. Kazaryan, R.S. Morozova, L.V. Serova, A.V. Ryazhskiy, A.N. Potapov, V.S. Romanov, V.B. Pishchik, and L.N. Grinberg

EXPERIMENT TITLE: Body Functions and Metabolism During Prolonged Hypokinesia in an Integrated Experiment

SUBJECTS: 2000 White rats

AREA OF STUDY: Metabolism and Energy Exchange; Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinesia in special cages for 120 to 170 days and subsequent normalization. Measurements: gas metabolism; oxidative phosphorylation; plastic metabolism; neuromuscular excitation; functional activity of the hypophyseal-adrenal cortex system; body weight.

IMMOBILIZATION METHOD: Cage

RESULTS: Prolonged restriction of motor activity caused significant changes in total gas and energy metabolism as well as in tissue oxidative processes. A sharp retardation of weight increase and a significant retardation of growth in the muscular system developed. The ultrastructure of tissues of the myocardium and liver became disturbed. Prolonged hypokinesia was accompanied by phasic changes in the functional activity of the hypophyseal-adrenal system and the thymolymphatic apparatus, and disturbance of serotonin metabolism. Transition to normal motor activity after prolonged hypokinesia did not normalize activity of the hypophyseal-adrenal system and serotonin metabolism for 30-40 days.

SOURCE: Uspekhi Fiziologicheskikh Nauk 6(3): 110-136, 1975

AUTHOR(S): Kovalenko, Ye.A. and A.V. Ryazhskiy

EXPERIMENT TITLE: Effect of Prolonged Hypokinesia on the Dynamics of PO_2 in the Cerebral Tissues of Rats During Orthostatic and Antiorthostatic Tests

SUBJECTS: Male white rats

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental rats were placed in special cages fitted to the size of the animals, which sharply restricted their mobility and forced them to remain in a horizontal position for 100 days. Electrodes were implanted to measure oxygen pressure (PO_2) during orthostatic tests (moving rat to an upright position). Measurement: PO_2 in cerebral tissues.

IMMOBILIZATION METHOD: Cage

RESULTS: Prolonged hypokinesia did not induce significant PO_2 changes in resting rats. PO_2 changed insignificantly during orthostatic tests but prolonged hypokinesia led to more marked changes in the PO_2 of rats exposed to an orthostatic test. Cerebral oxygenation changes in hypokinetic rats were variable and inadequate, differing appreciably from those in controls.

SOURCE: Space Biology and Aerospace Medicine 10(6): 33-36, 1976

AUTHOR(S): Krasnykh, I.G. and L.A. Tyutin

EXPERIMENT TITLE: Motor-Evacuation Function of the Gastrointestinal Tract in Dogs During Prolonged Hypodynamia

SUBJECTS: 29 Dogs

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Three series: 1) 15-day hypokinesia, 10 dogs; 2) 30-day hypokinesia, 10 dogs; 3) 60-day hypokinesia, 9 dogs. For most of the dogs, hypodynamia was created by placing them in special cages with a variable volume. In 5 of 10 dogs in series 1, hypodynamia was induced by confining them in plaster in a special stand. The motor-evacuatory function of the gastrointestinal tract was investigated by serial radiography. Diet: fed twice a day; meat soups, white bread, 150-200 gm meat.

IMMOBILIZATION METHOD: Cage; Plaster

RESULTS: An exposure to 15-day hypokinesia delayed bowel evacuation by an average of 1.4 hr; 6 of the dogs showed pyloric spasms. Bowel evacuation ended 30 hr later than it had before hypodynamic exposure. During 60-day hypokinesia the pyloric spasm lasted 2-4 hr. The time of evacuation exceeded the pretest date 2-fold and that of the large intestine, 4-fold. The functional changes were attributed to motor-visceral gastrointestinal tract disturbances.

SOURCE: Space Biology and Medicine 7(5): 57-64, 1973

AUTHOR(S): Kravchuk, L.A. and V.G. Ovechkin

EXPERIMENT TITLE: Effect of Amobarbital Sodium and the Somatotrophic Syndrome on Mice During Prolonged Hypokinesia

SUBJECTS: 90 Male white mice (18-20 gm)

AREA OF STUDY: Pharmacology

OBJECTIVES: In title

PROTOCOL: Three groups of 30 each: 1) control; 2) isolation; 3) isolation plus restraint. Experiment lasted 37 days. Amobarbital sodium administered ip on 35th day. Solution of human somatotrophic hormone administered on 37th day, with repeated administration of amobarbital sodium after 2-8 hr. Diet: carrots and water. Measurements: mortality; body weight; pulse; respiration; food and water consumption; orthostatic tolerance; observed behavior; sensitivity to amobarbital sodium by itself and with somatotrophic hormone.

IMMOBILIZATION METHOD: Cage (mechanical restriction in small cage)

RESULTS: There was increased excitability and aggressiveness in the 2 isolated groups during the 1st wk; reduced agitation after the 7th, 10th day of confinement. Restrained mice showed the lowest mean food consumption. There was a markedly higher weight gain in controls. The mortality rate was higher (33.3%) in the restrained group. Pulse and respiration measurements indicated changes in cardiovascular and respiratory function with prolonged isolation and restricted mobility. The onset of amobarbital sodium effects developed sooner in the isolated groups compared to the controls. Initial effects developed most quickly in the restrained group, with even more prolonged and strongly expressed periods of excitability, but a shortened sleep duration.

SOURCE: Space Biology and Medicine 2(3): 8-15, 1968

AUTHOR(S): Kravchuk, L.A.

EXPERIMENT TITLE: Soporific and Toxic Effect of Amobarbital Sodium
During 33-Day Hypokinesia and Isolation of Mice

SUBJECTS: 90 White male mice (17-19 gm)

AREA OF STUDY: Pharmacology

OBJECTIVES: In title

PROTOCOL: Three groups of 30 each: 1) control; 2) isolation; 3) isolation plus hypokinesia. All animals were tested after 30 days in the following way. Amobarbital sodium (producing brief sleep) was injected ip on the 31st day and a toxic dose administered on the 34th day. Measurements: mortality; body weight; body temperature; pulse; food and water consumption; orthostatic tolerance; behavior; sensitivity to amobarbital sodium.

IMMOBILIZATION METHOD: Cage (mechanical restriction in small cage)

RESULTS: Immobilized mice showed a lag in body weight. A slight hypothermia of 1.5° - 2.0° was evident in all mice. Some control animals (3%) died for no apparent reason while 26.6% of immobilized animals died. Amobarbital sodium exerted its soporific effect at a lower dose and more rapidly in immobilized animals, and the duration of sleep was greater. LD₅₀ was less in immobilized than control animals.

SOURCE: Space Biology and Medicine 5(5): 137-140, 1971

AUTHOR(S): Krempien, B., Ch. Manegold, E. Ritz, and J. Bommer

EXPERIMENT TITLE: The Influence of Immobilization on Osteocyte Morphology:
Osteocyte Differential Count and Electron Microscopical
Studies

SUBJECTS: Female Wistar rats (150 gm)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Two series of experiments: 1) osteocyte differential counts, 3 wk immobilization - 2 groups: a) spinal paraplegia, severing of the spinal cord of the lumbar vertebral column 2 cm above the pelvis; b) application of a pelvic plaster cast to the lower extremities. Some of the rats in group 1 were parathyroidectomized before immobilization. Food and water intake were unrestricted. Rats were killed after immobilization, and tibiae and femora were removed for analysis. 2) Electron microscopical studies, 10 days - ischiatic nerve dissection, severed at the midpoint of the femur, extremity sewn into abdominal wall. Muscles and circulation remained intact. Measurements: osteocyte count and histogram; electron microscopy.

IMMOBILIZATION METHOD: Cast; Cordotomy; Denervation

RESULTS: The cortical bone of the paraplegmized animals and those immobilized by plaster cast showed a great increase in the number of enlarged osteocytes which were located in an irregular oval lacuna. There were a significantly increased number of empty lacunae. The number of activated, enlarged osteocytes in nonparathyroidectomized animals showed no increase in the number of enlarged osteocytes. Electron microscopical studies of undecalcified tibiae showed a peri-osteocytic osteolysis with destruction of the lacunar wall, fragmentation of collagen fibers and loss of mineral crystals. The cytoplasmic seams of osteocytes were broadened, mitochondria were enlarged, and the cytoplasm showed vacuoles containing amorphous material which could be found in the pericellular space. Deep invaginations of the cytoplasm and an increase of the cell processes were typical findings.

SOURCE: Virchows Archiv. A. Pathological Anatomy and Histology
370(1): 55-68, 1976

AUTHOR(S): Krisch, B.

EXPERIMENT TITLE: Altered Pattern of Vasopressin Distribution in the Hypothalamus of Rats Subjected to Immobilization Stress

SUBJECTS: Wistar-Hannover rats, 3 mo old

AREA OF STUDY: Nervous; Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) rats were immobilized in a prone position with their heads and all 4 limbs fixed for 5 min, subjects sacrificed after 5, 15 and 30 min, all animals were anesthetized by ip injection of Nembutal, animals in diestrus and estrus were selected on the day of sacrifice. Measurements: vasopressin; immunohistochemical studies.

IMMOBILIZATION METHOD: Fixation of head/extremities in prone position

RESULTS: After a survival period of 5 min the vasopressin-synthesizing part of the paraventricular nucleus exhibited an increased activity. Vasopressin-reactive axons in the pericapillary layer of the median eminence and among the solid cell clusters of the pars tuberalis became more conspicuous and increased in number. In this group, the prechiasmatic division of the supraoptic nucleus did not show any changes in immunoreactivity. The same held true for the neurohypophyses in all experimental groups. In animals with increased survival times the supraoptic nucleus exhibited a slightly increased activity, whereas the staining intensity of the paraventricular nucleus decreased gradually.

SOURCE: Cell and Tissue Research 189: 267-275, 1978

AUTHOR(S): Krokhina, E.M., Y.G. Skotselyas, and E.A. Yumatov

EXPERIMENT TITLE: Disturbances of the Adrenergic Innervation of the Stomach in Rats with Stable Control of Cardiovascular Functions During Emotional Stress

SUBJECTS: 15 Male Wistar rats (250 gm)

AREA OF STUDY: Circulatory; Digestive

OBJECTIVES: In title

PROTOCOL: Three groups: 1) immobilization - 8 rats, induced by placing animals in a restrictive chamber for 30 hr; 2) 4 controls; 3) 3 intact rats. Blood pressure was recorded dynamically through a catheter inserted into the caudal artery throughout the experiment in groups 1 and 2. Animals were killed by decapitation. Measurements: examination of the gastric mucosa; blood pressure; heart rate; change in the adrenergic innervation.

IMMOBILIZATION METHOD: Chamber (restrictive)

RESULTS: Measurement of the blood pressure during 30 hr immobilization revealed stability of the cardiovascular functions during exposure to emotional stress. The blood pressure and heart rate of the experimental rats were indistinguishable from those of the controls kept under conditions of free behavior. In 6 of the 8 immobilized rats histochemical investigation of the stomach showed that mobilization of the adrenergic innervation was present in the stomach wall, as reflected in an increase in the number of adrenergic axons innervating all types of blood vessels. Changes were found in the nerve fibers and endings in the stomach of the experimental animals: the sites of accumulation and storage of mediator grew larger and resembled varicosities. Degeneration of the gastric mucosa was found in both groups of rats.

SOURCE: Bulletin of Experimental Biology and Medicine 84(10): 1522-1525, 1977

AUTHOR(S): Krotov, V.P.

EXPERIMENT TITLE: Study of Water-Mineral Metabolism During Restricted Motor Activity

SUBJECTS: 68 Rabbits

AREA OF STUDY: Fluid and Electrolyte; Muscular; Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 26 controls; 2) 42 rabbits, restriction of motor activity was achieved by placement in specially designed cages. Rabbits were killed by an electric current on days 7, 15, 20, 30, 40 and 45 of hypokinesia. Measurements: water, potassium and sodium content of cardiac muscle, thigh extensor, and long muscle of back; serum protein; hematocrit; hemoglobin; potassium, sodium and calcium in plasma and blood; volume of plasma, extracellular fluid and total body water.

IMMOBILIZATION METHOD: Cage (3 changeable dimensions)

RESULTS: Under hypokinesia, plasma liquefaction was noted along with a decrease in the hematocritic index and hemoglobin concentration. Plasma volume increased 5.1%. Fluid redistribution occurred between plasma and red blood cells. Potassium and sodium concentration in plasma decreased with lengthening of hypokinesia. The pattern of changes in the plasma calcium concentration correlated with the variations in total blood serum protein. Potassium and sodium in various myocardial parts varied. There were no significant changes in electrolyte content in femur extensor and long muscle of the back. Dehydration did not occur during hypokinetic exposure.

SOURCE: Space Biology and Medicine 6(2): 106-118, 1972

AUTHOR(S): Krupina, T.N., B.M. Fedorov, T.V. Benevolenskaya, O.I. Boykova, V.S. Nevstruyeva, Ye.N. Kul'kov, R.S. Morozov, and V.S. Romanov

EXPERIMENT TITLE: Changes in Cardiac Activity During Prolonged Restriction of Motor Activity

SUBJECTS: 60 Rabbits

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Rabbits were kept in cages which sharply restricted their mobility for 2.5 mo. Measurements: EKG, using silver electrodes implanted under the skin; catecholamines; myocardial and hypothalamic noradrenaline; myocardial and suprarenal adrenaline; 11-oxycorticosteroids in peripheral blood plasma; electron microscopy of the myocardial ultrastructures. Additionally, 10 male subjects subjected to 120 days of bedrest were studied.

IMMOBILIZATION METHOD: Cage

RESULTS: The initial heart rhythm was 160-200 contractions/min; there was no significant difference the 3rd week of hypokinesia. By day 12-14, myocardial noradrenaline was reduced by more than half, and remained reduced on day 30. There was a considerable decrease of noradrenaline in hypothalamic tissues. Myocardial adrenaline content was unchanged on days 12-14 of hypokinesia, but suprarenal adrenaline had decreased slightly. By day 30, adrenaline in the suprarenals had decreased by a factor of 2.5. Peripheral blood plasma 11-oxycorticosteroids was reduced by half on day 12 and more than threefold by day 30. Capillary changes were observed by day 12, and muscle fibers showed endemic foci. By day 30, there was lysis of individual myofibrils and lipid granules in the sarcoplasm; mitochondria were distended and the number of cristae decreased.

SOURCE: Space Biology and Medicine 5(2): 111-119, 1971

AUTHOR(S): Kryshen, P.F., A.A. Kolpakov, Yu.I. Tkach, I.V. Sakovich,
and N.A. Chuich

EXPERIMENT TITLE: Dependence of Pathomorphological Changes in the Gastric
Mucosa on the Functional Condition of the Cortex and
Subcortical Formations of the Brain

SUBJECTS: 15 Random-bred rats (175-292 gm)

AREA OF STUDY: Nervous; Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) fixed immovably on a board for 24 hr, 10 rats;
2) 5 controls. The craniums were laid bare under ether narcosis, and
nichrome needle electrodes were inserted through the trepanation openings
to the cortex of the cerebellar vermis, the somatosensory zone of the
cerebral cortex and the hypothalamus. Measurements: electrocorticogram
(ECoG); electrohypothalamogram (EHG); electrocerebellogram (ECeG), and EKG;
respiration rate; macro- and microscopic study of change in stomach, liver
and intestine.

IMMOBILIZATION METHOD: Board

RESULTS: Two periods were observed during the day-long immobilization:
agitation and depression. In the initial state the number of waves and
their amplitude were: 18.4 ± 1.2 per sec and 35.5 ± 2.2 μ V on the ECoG;
 20.2 ± 1.3 per sec and 27.2 ± 3.0 μ V on the EHG and 19.9 ± 0.8 per sec
and 13.7 ± 1.3 μ V on the ECeG. The pulse rate was 432 ± 14 per min and
the respiration rate 89.3 ± 3.16 per min. After 4-5 hr the average number
of waves decreased on the ECoG to 81.5%, EHG to 77.7%, and ECeG to 64.3%.
The heart and respiratory frequencies reached maximum values for each
animal after 4-5 hr. After 20-24 hr, the "pathological complexes" length-
ened in duration and decreased in number of waves in each. Depression
of the respiratory and cardiac functions were noticeable. Upon autopsy
hyperemia, edema of the stomach wall, and numerous hemorrhages in the
mucosa at the apexes of folds in all sections of the glandular stomach were
found. Clearly plethoric and dilated vessels were found microscopically
in the stomach tissues.

SOURCE: Patologicheskaya Fiziologiya i Eksperimentalnaya Terapiya
16(6): 48-51, 1972

AUTHOR(S): Kudryashov, B.A., E.G. Lomovskaya, F.B. Shapiro, and
L. Ya. Lyapina

EXPERIMENT TITLE: The Effects of Adrenalectomy and Corticosteroid
Injection on the Fibrinolytic Activity of Complex
Heparin Compounds in the Blood During Immobilization

SUBJECTS: Female rats (170-200 gm)

AREA OF STUDY: Endocrine; Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 8-12 days after adrenalectomy, stress was induced by 30 min restraint by tying the rats to a peg; 2) intact controls. Blood was taken and total blood fibrinolytic activity and nonenzymatic fibrinolysis was determined. Fractional separation of the following complex heparin compounds was carried out: with fibrinogen (FG); epinephrine (ENP), plasminogen (PMG), and plasmin (PM), and determination of their complex activity was carried out.

IMMOBILIZATION METHOD: Tying to a peg

RESULTS: Stress in intact rats caused an increase in total non-enzymatic fibrinolytic activity. ENP complex activity also grew sharply while the activity of FG, PMG and PM increased more than 2-5 times. When adrenalectomized animals were subjected to stress, complexing occurred no more intensely than in intact animals not subjected to stress. When blood corticosteroid levels were raised in adrenalectomized animals, they began to react to stress with as intensive a process of heparin complex formation as the intact animals.

SOURCE: Fiziologicheskii Zhurnal SSSR Imeni I M Sechenova
59(7): 1108-1113, 1973

AUTHOR(S): Kudryashov, B.A., F.B. Shapiro, E.G. Lomovskaya, and L.A. Lyapina

EXPERIMENT TITLE: Significance of Adrenalin and ACTH for the Process of Formation of Complex Heparin Compounds in the Blood in Immobilization Stress

SUBJECTS: 202 Male rats (170-200 gm)

AREA OF STUDY: Blood; Endocrine

OBJECTIVES: In title

PROTOCOL: Eleven groups: 1) intact, not immobilized; 2) intact, immobilized; 3) ACTH blockage by ip DOCA, immobilized; 4) solvent ip immobilized; 5) phentolamine hydrochloride α -blocker iv, immobilized; 6) inderal β -blocker iv, immobilized; 7) physiological solution iv immobilized; 8) ACTH iv after 30 min, immobilized; 9) physiological solution iv after 30 min, immobilized; 10) adrenalin iv after 30 min, immobilized; 11) ACTH ip + adrenalin iv after 30 min, immobilized. Rats were immobilized by being tied to a table. Measurements: total fibrinolytic activity, non-enzymatic fibrinolytic activity and fibrinogen, adrenalin, plasminogen, and plasmin complex activities were decided from the size of the lysis zones in mm on the fibrin plates. The size of these zones are a direct consequence of adrenalin and ACTH discharge by the adrenal cortex.

IMMOBILIZATION METHOD: Tied to table

RESULTS: In animals where ACTH secretion was blocked by DOCA administration, the nonenzymatic fibrinolytic activity under stress did not differ with the control. This activity also did not differ with the control group after the α -adrenoceptors were blocked with phentolamine hydrochloride, and after β -adrenoceptors were blocked with inderal. Separate administration of both ACTH and adrenalin intensified heparin complex formation equally under stress, but combination of administration of the two could not sum, or double, the effect.

SOURCE: Problemy Endokrinologii 21(5): 54-59, 1975

AUTHOR(S): Kudryashov, B.A., F.B. Shapiro, E.G. Lomovskaya, and
L.A. Lyapina

EXPERIMENT TITLE: The Role of ACTH and Glucocorticoids in Nonenzymatic
Fibrinolysis During Immobilization Stress in Animals

SUBJECTS: Mongrel male rats (170-200 gm)

AREA OF STUDY: Blood; Endocrine

OBJECTIVES: In title

PROTOCOL: Four groups: 1) controls administered physiological solution; 2) rats restrained for 30 min by tying to a table; 3) rats received from .1-.5 ml of protamine sulfate iv, 5 units of ACTH and 1 and 2 mg/100 gm of hydroxycortisone 15 min after administration of protamine sulfate, then restrained for 30 min; 4) adrenalectomized rats administered physiological saline or protamine sulfate or protamine sulfate plus ACTH or protamine sulfate plus hydrocortisone or all 3. Measurements: blood was taken from the jugular vein and analyzed for total fibrinolytic activity.

IMMOBILIZATION METHOD: Tying to a table

RESULTS: The threshold dose of protamine sulfate for bonding heparin in vivo was determined to be 0.2 ml of a .01% solution. The administration of ACTH after a threshold dose of protamine caused the formation of complex heparin compounds to resume; nonenzymatic fibrinolysis attained the level characteristic for combined immobilization stress and ACTH. Administration of 1 mg/100 gm of hydrocortisone plus protamine sulfate did not result in a new release of heparin; nonenzymatic fibrinolytic activity was the same as with protamine administration only. The administration of ACTH during immobilization increased the absolute amount of nonenzymatic fibrinolytic activity 2.5 times (from 32.9 to 80.3 mm) and its percentage in the total fibrinolytic activity of blood from 40 to 60%. In adrenalectomized rats administered ACTH and protamine sulfate, nonenzymatic fibrinolysis was 40% lower than in adrenalectomized restrained rats.

SOURCE: Fiziologicheskii Zhurnal SSSR Imeni I M Sechenova 63(5):
735-741, 1977

AUTHOR(S): Kudryashov, B.A., F.B. Shapiro, and A.M. Ul'yanov

EXPERIMENT TITLE: Participation of the Hypophysis-Adrenal Cortex System in Thrombin Clearance During Immobilization Stress

SUBJECTS: 57 Male rats (180-220 gm)

AREA OF STUDY: Blood; Endocrine

OBJECTIVES: In title

PROTOCOL: Ten groups: 1) intact, nonimmobilized; 2) intact, immobilized; 3) adrenalectomized, nonimmobilized; 4) adrenalectomized, immobilized; 5) adrenalectomized, immobilized + NaCl solution; 6) adrenalectomized, immobilized + hydrocortisone; 7) adrenalectomized, nonimmobilized, hydrocortisone beforehand; 8) intact, immobilized + ACTH; 9) adrenalectomized, immobilized + ACTH; 10) adrenalectomized, immobilized + ACTH + hydrocortisone. Immobilization was accomplished by tying the rat to a platform for 30 min. Animals were used in the tests 6-7 days and 48 hr after adrenalectomy. The thrombin preparation that was injected into the rats was labeled with ^{131}I . The rats were killed 5 and 10 min after the administration of thrombin- ^{131}I . The radioactivity of the liver, lung and spleen was calculated in percent of the specific radioactivity of the blood. Measurements: the rate of elimination of thrombin ^{131}I from the blood stream and its accumulation in the liver, lungs, and spleen.

IMMOBILIZATION METHOD: Tying to a platform.

RESULTS: The specific radioactivity of intact animals decreased rapidly, even more so under stress. However, thrombin clearance in adrenalectomized animals was greatly inhibited, and among those subjected to stress, the clearance rate matched that of intact unstressed animals. As a result of the slower removal of thrombin from the blood streams of the adrenalectomized animals, the accumulation of thrombin in their livers and lungs decreased. Accumulation of thrombin in the spleen was insignificant. Administration of hydrocortisone returned thrombin clearance to normal in adrenalectomized rats, but only administration of ACTH to intact rats even further increased thrombin clearance. The administration of ACTH to adrenalectomized animals only stimulated thrombin clearance when adrenals were compensated for with exogenous hydrocortisone.

SOURCE: Problemy Endokrinologii 23(6): 43-48, 1977

AUTHOR(S): Kunc1, R.W. and H.Y. Meltzer

EXPERIMENT TITLE: Pathologic Effect of Phencyclidine and Restraint
on Rat Skeletal Muscle Structure: Prevention by
Prior Denervation

SUBJECTS: Male Sprague-Dawley rats (160-200 gm)

AREA OF STUDY: Muscular; Pharmacology

OBJECTIVES: In title

PROTOCOL: Restraint: 2 hr at room temperature (25-27°C) by placing rats in rigid lucite cages. A single 5 mg/kg dose of phencyclidine was given 15 min prior to restraint and, in some studies, given daily for 5 or 28 days; controls received ip saline. Phencyclidine and restraint were performed 40-48 hr postdenervation. In some studies, rats were examined immediately, 7 or 14 days postrestraint. All were autopsied 24 hr postrestraint. Diet: Purina rat chow; water ad libitum.

IMMOBILIZATION METHOD: Cage (rigid lucite)

RESULTS: Extensive disruptions of myofibrillar architecture or extensive areas of Z-band smearing occurred in less than 2% of skeletal muscle fibers of the vastus lateralis muscle of controls. 2-hr restraint did not significantly increase extensive myofibrillar disruption and acute or chronic administration of phencyclidine had only a slight effect on rat muscle morphology. Phencyclidine plus restraint produced extensive areas of myofibrillar disruption and extensive Z-band smearing and scattered, segmented necrosis. Denervation of quadriceps femoris almost completely blocked the occurrence of any lesions.

SOURCE: Experimental Neurology 45(2): 387-402, 1974

AUTHOR(S): Kundrotas, L.W. and R.V. Gregg

EXPERIMENT TITLE: Urinary Excretion of 5-Hydroxyindoleacetic Acid (5-HIAA) in the Rat After Immobilization Stress

SUBJECTS: Adult Sprague-Dawley rats (165-195 gm)

AREA OF STUDY: Fluid and Electrolyte; Digestive

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 30 rats, free access to food and water after the initial starvation; 2) 30 rats, deprived of food and water for the experimental period; 3) 35 rats, restrained by wire mesh corsets with holes cut for the limbs molded around the body of each, feet were bound by adhesive tape, the front pair together, the rear pair apart; food and water deprived. Diet: Purina Laboratory Chow and water ad libitum until the day before the experiment. Urine collection from all groups. Measurements: 5-HIAA; ulceration of stomach.

IMMOBILIZATION METHOD: Corset

RESULTS: An increase of 100% in urinary 5-HIAA was observed in the restrained rats. 70% of restrained rats developed gastric ulcers. In group 2 the additional 18 hr of starvation had no effect on the level of 5-HIAA excreted.

SOURCE: Physiology and Behavior 19: 739-741, 1977

AUTHOR(S): Kupriyanov, V.V., V.G. Petrukhin, N.I. Novikov, N.A. Gaydamakin, I.G. Krasnykh, V.I. Solov'yev, V.B. Vlasov, and S.V. Petrukhin

EXPERIMENT TITLE: Effects of Long-Term Hypokinesia on Tissue and Extremity Vessels in Experiments (On Dogs)

SUBJECTS: 16 Dogs

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 8 controls; 2) 6 experimental dogs in cages of changing size for 6 mo and then killed; and 3) 2 experimental dogs in cages for 6 mo, 1 mo free movement and then killed. Measurements: body weight; thickness of the extremity tissues; states of the vascular, arterial and venous bed, tubular bones, articular bursae, fasciae and muscular tissue; activity of the following enzymes in the muscle tissue: succinate dehydrogen (SDH), lactate (LDH), α -glycerophosphate (GPDH), glutamate (GDH), dihydroorotate (DDH), gluco-6-phosphate (G-6-DH), inosine-5-phosphate (I-5-PDH), monoaminoxidase (MAO), acid (AP), and alkali (ALP) phosphatase. Intravital roentgenologic, anatomical, histochemical, and electron-microscopic methods were used.

IMMOBILIZATION METHOD: Cage (changeable dimensions)

RESULTS: Hypokinesia resulted in substantial alterations in the macro- and micro-ultrastructural level of the vascular bed, metabolic disturbance, and in extremities' tissue focal reconstruction by the type of natural death of the ultrastructural elements without subsequent repair. A one-month period appeared to be insufficient for repair of structural disorders. Indications of blood transfer via extracapillary pathways from the arterial bed into the venous bed were noted.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 69(11): 39-46, 1975

AUTHOR(S): Kurakami, K.

EXPERIMENT TITLE: Studies on Changes of Rabbit Skeletal Muscle Components Induced by Immobilization with Plaster Cast

SUBJECTS: White adult male rabbits (2.5 kg)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: The left hind limb of the rabbit was immobilized in a plaster cast with the knee joint maximally flexed and the ankle joint maximally extended. At this position, the gastrocnemius was relaxed and the tibialis anterior muscle was extended. The contralateral limb served as the control. Rabbits were immobilized for 1-7 wk; some were used in a recovery study of 4 wk after 2 weeks of immobilization; some were given daily ATP (2.5 mg/kg) for 1-4 wk while both immobilized and free. Measurements of gastrocnemius and tibialis anterior: wet weight; actomyosin; ATP-ase activity; myofibrils, total water, Na⁺, K⁺ and lipid content, creatine phosphate.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: The wet weight of the immobilized tibialis anterior (TA) muscle increased for 5 wk then decreased; the gastrocnemius (G) gradually decreased. The relative ATPase activity of actomyosin from the TA was activated for up to 3 wk, while the G decreased monophasically with time. Myofibrillar ATPase activity showed the same tendency. There were no significant differences in water content between normal and immobilized muscles; Na⁺ increased in both fixed muscles, particularly in the G. K⁺ decreased gradually in both muscles; the amount of lipid in the G, but not the TA, increased after 4 wk immobilization. Creatine phosphate content decreased in both muscles; ATP had no effect. There were significant differences in the recovery process; muscles immobilized for 2 wk regained 85% of the weight in 2 wk; muscles immobilized for 3 wk had only recovered 75% after 5 wk. ATP administration was ineffective in decelerating atrophy, but accelerated recovery when given during immobilization.

SOURCE: Nagoya Medical Journal 12(3): 165-184, 1966

AUTHOR(S): Kurtser, B.M., L.N. Kobylanskiy, S.A. Lysenko, and L.I. Tkachenko

EXPERIMENT TITLE: Free Amino Acids of the Blood and Some Organs in Hypokinesia

SUBJECTS: Male rats (186.2 ± 2.0 gm)

AREA OF STUDY: Blood; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinesia, 20 rats maintained in special cages for 10 days. Diet: standard food ration. Animals were killed by decapitation, blood was taken immediately after, and tissues taken from the liver, kidneys, brain, skeletal and cardiac muscles. Measurements: body weight and temperature; content of free amino acids.

IMMOBILIZATION METHOD: Cage

PROTOCOL: Limited mobility led to a significant reduction in the body weight and an insignificant reduction in temperature. The content of free amino acids was on the average 19% lower than in controls. The most pronounced decrease was found in tissue of the brain (72.5%), myocardium (75%), and blood (64.1%). The content of cystine, alanine and glycine was low in the blood and all the studied tissues, while the content of phenylalanine was high. There was an unequal content of individual amino acids in different tissues.

SOURCE: Zdravookhranenie 18(4): 26-27, 1975

AUTHOR(S): Kustov, V.V., V.I. Belkin, B.I. Abidin, T.A. Lekareva,
L.T. Poddubnaya, and O.F. Ostapenko

EXPERIMENT TITLE: Effect of Restricted Mobility of Animals on the
Intensity and Excretion of Some Gaseous Products
of Vital Functions

SUBJECTS: Male white rats (200 gm)

AREA OF STUDY: Respiratory

OBJECTIVES: In title

PROTOCOL: The mobility of the rats was restricted by placing them in specially constructed cages for 24 hr, 3 and 15 days. Following hypokinesia, the cages were placed in a pressurized chamber (volume, 93 liters) with a constant temperature (18-20°) and relative humidity (not over 60%). The condensate was analyzed. Measurements: carbon monoxide; ammonia; aldehydes; formaldehyde; ketones.

IMMOBILIZATION METHOD: Cage

RESULTS: Hypokinesia had an insignificant effect on the elimination of ketones and aldehydes but accelerated the elimination of carbon monoxide and ammonia.

SOURCE: Space Biology and Medicine 5(2): 14-19, 1971.

AUTHOR(S): Kustov, V.V., B.I. Abidin, V.I. Belkin, and L.T. Poddubnaya

EXPERIMENT TITLE: Effect of Preliminary Exposure to Carbon Monoxide
on Development of Hypokinetic Disorders in White Rats

SUBJECTS: 90 White male rats (130-150 gm)

AREA OF STUDY: Respiratory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control rats were kept in a sealed chamber ventilated with room air; 2) experimental rats were poisoned by carbon monoxide ($0.6 \pm .02$ mg/liter) for 4 hr/day for 10 days. On the 10th day of the experiment, all animals were placed in hypokinetic cages. Measurements were made on the 10th and 20th days of the experiment; body weight; oxygen consumption; number of erythrocytes and hemoglobin content in the peripheral blood; carboxyhemoglobin in the blood; succinate dehydrogenase activity in the liver tissue; activity of renal cytochromoxidase.

IMMOBILIZATION METHOD: Cage

RESULTS: For both control and experimental rats carbon monoxide exposure for 10 days did not have a significant effect on weight increment, intensity of oxygen consumption and carboxyhemoglobin level in the blood, and caused no shifts in activity of liver catalase. Carbon monoxide exposure did cause a significant increase in the number of erythrocytes, the quantity of hemoglobin in the peripheral blood, and blood catalase activity. It caused a decrease in the time for denaturation of hemoglobin by alkali, and an increase in blood catalase activity. In the experimental rats there was a substantial decrease in the activity of cytochromoxidase and succinate dehydrogenase in the liver. On the 20th day, oxygen consumption was increased, the number of erythrocytes was increased in the control animals and decreased in the experimental rats. The blood catalase index decreased in both groups but at a greater rate in experimental rats. Liver catalase decreased in both groups; activity of liver cytochromoxidase increased; succinate dehydrogenase in liver tissue decreased in control rats and increased in experimental animals. The mortality rate was 4 times greater for the experimental group.

SOURCE: Space Biology and Medicine 6(4): 27-32, 1972

AUTHOR(S): Kustov, V.V., B.I. Abidin, V.I. Belkin, and T.A. Lekareva

EXPERIMENT TITLE: Influence of Hyperoxia and Hypokinesia on the Formation and Elimination of the Gaseous Products of Vital Functions in Rats

SUBJECTS: White male rats (180-200 gm)

AREA OF STUDY: Respiratory

OBJECTIVES: In title

PROTOCOL: Restraint: 3, 15 and 30 days. The animals were placed in hypokinetic cages which were kept in a sealed chamber with the oxygen content maintained at the level 320-340 mm Hg. Following restraint, rats were shifted to a smaller cage to collect condensate of atmospheric moisture. Measurements: body elimination of carbon monoxide, ammonia, aldehydes, and ketones; ammonia and carboxyhemoglobin in the blood.

IMMOBILIZATION METHOD: Cage

RESULTS: Thirty-day exposure to hypokinesia and moderate hyperoxia decreased elimination of ammonia and increased the entrance of carbon monoxide, aldehydes and ketones into an enclosed atmosphere. The production level of compounds containing porphyrin, nitrogen, fats and carbohydrates was higher under the combined rather than separate influence of hypokinesia and moderate hyperoxia.

SOURCE: Space Biology and Medicine 10(1): 110-115, 1976

AUTHOR(S): Kvetnansky, R., A. Mitro, L. Mikulaj, and G. Hocman

EXPERIMENT TITLE: Catecholamines of the Adrenal Medulla and Their Morphological Changes During Adaptation to Repeated Immobilization Stress

SUBJECTS: Wistar rats (180-200 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Rats were immobilized daily for 2.5 hr by fixation of the animals with adhesive tape to a solid plate. 3 groups: 1) 6 rats, controls; 2) 7 rats, 3 days of immobilization; and 3) 9 rats, 45 days of immobilization. The animals were decapitated after immobilization, and the adrenal medulla was removed. Measurements: catecholamine content and weight of adrenal medulla.

IMMOBILIZATION METHOD: Plate and adhesive tape

RESULTS: The weight of the adrenal medulla increased significantly in rats immobilized for 45 days as compared to the controls and the animals immobilized for 3 days. The number of cells in the adrenal medulla per area unit did not show any significant difference during immobilization. The level of catecholamines increased significantly in the rats immobilized for 45 days in comparison to the control animals or animals immobilized for 3 days. After the 3rd day of fixation the level of catecholamines decreased, but not enough to be statistically significant.

SOURCE: Bratislavske Lekarske Listy 46(1): 35-41, 1966

AUTHOR(S): Kvetnansky, R., G.P. Gewirtz, V.K. Weise, and I.J. Kopin

EXPERIMENT TITLE: Effect of Hypophysectomy on Immobilization-Induced Elevation of Tyrosine Hydroxylase and Phenylethanolamine-N-methyl Transferase in the Rat Adrenal

SUBJECTS: Male Sprague-Dawley rats (180-220 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Hypophysectomized and sham-operated rats were immobilized in a prone position for 2.5 hr daily by inserting their heads through 2 parallel concentric steel wire loops fixed on a metal plate and fastening their limbs with adhesive tape to 4 metal strips. The animals were decapitated 6 hr after the first or seventh interval of immobilization, and the adrenal glands were removed. In some experiments, hypophysectomized rats were given injections (adrenocorticotrophic hormone 5 IU sc; dexamethasone-21-phosphate 1 mg sc; L-thyroxine, sodium salt 10 µg sc; or 0.9% sodium chloride) 60 min before the daily immobilization period. Measurements: adrenal catecholamine, tyrosine hydroxylase (TH), and phenylethanolamine-N-methyl transferase (PNMT).

IMMOBILIZATION METHOD: Wire loops, metal strips, tape, and metal plate

RESULTS: Six hr after a single 2.5-hr immobilization adrenal epinephrine was decreased in both hypophysectomized and sham-operated animals. Six hr after the last immobilization epinephrine had decreased even further in the hypophysectomized rats. TH and PNMT were decreased following hypophysectomy. After repeated immobilization TH levels in hypophysectomized rats increased significantly but did not reach control levels. In hypophysectomized rats, PNMT levels remained markedly decreased with repeated immobilization. When ACTH was administered to hypophysectomized rats before each period of immobilization there was less depletion of adrenal epinephrine and levels of TH and PNMT approached those found in sham-hypophysectomized immobilized rats. When dexamethasone was given prior to immobilization there was again less depletion of adrenal epinephrine and an increase in PNMT levels but no change in TH levels. Thyroxine did not increase epinephrine or enzyme levels in hypophysectomized immobilized rats.

SOURCE: Endocrinology 87: 1323-1329, 1970

AUTHOR(S): Kvetnansky, R. and L. Mikulaj

EXPERIMENT TITLE: Adrenal and Urinary Catecholamines in Rats during Adaptation to Repeated Immobilization Stress

SUBJECTS: Male Wistar rats (~200 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Rats were subjected to one immobilization stress (3, 6, 12, 18 and 24 hr) or to repeated daily immobilization for 2.5 hr (1-350 days). Animals were immobilized by inserting their heads through 2 metal loops and taping their limbs to metal mounts attached to a board. After varying periods of immobilization or repeated immobilization, the animals were decapitated. Measurements: adrenal and urinary catecholamines.

IMMOBILIZATION METHOD: Metal loops, tape, metal mounts, and board

RESULTS: A decrease in adrenal epinephrine was apparent after 90 min of the first immobilization and persisted for 24 hr after the immobilization was terminated. Adrenal norepinephrine was not affected. Urinary epinephrine and norepinephrine (24-hr excretion) were increased by one immobilization; most of these catecholamines were excreted during the interval of immobilization. After daily repeated immobilization for 2.5 hr, "adaptation" of the adrenal medulla appeared to occur. Immediately after the ninth immobilization adrenal epinephrine was still decreased, but 24 hr later it was at the control level. After 40-350 times repeated immobilization, adrenal epinephrine was not decreased and adrenal norepinephrine was increased. Urinary excretion of epinephrine was greater in rats subjected to repeated immobilization than in unstressed or once-immobilized rats.

SOURCE: Endocrinology 87: 738-743, 1970

AUTHOR(S): Kvetnansky, R., V.K. Weise, and I.J.Kopin

EXPERIMENT TITLE: Elevation of Adrenal Tyrosine Hydroxylase and Phenylethanolamine-N-Methyl Transferase by Repeated Immobilization of Rats

SUBJECTS: Male Sprague-Dawley rats (180-250 gm)

DISCIPLINE(S): Endocrine

OBJECTIVES: In title

PROTOCOL: Rats were immobilized in a prone position for 2.5 hr daily (except Sunday) for 1, 7 and 42 days by inserting their heads through 2 parallel concentric steel wire loops fixed on a metal plate and fastening their limbs with adhesive tape to 4 metal strips. The rats were killed by decapitation immediately or 6 hr after the last interval of immobilization; adrenal glands were removed. Measurements: adrenal tyrosine hydroxylase and phenylethanolamine-N-methyl transferase.

IMMOBILIZATION METHOD: Wire loops, metal strips, tape, and metal plate

RESULTS: Repeated daily immobilization of rats resulted in a neuronally dependent elevation of tyrosine hydroxylase in the adrenal medulla. Phenylethanolamine-N-methyl transferase levels were also increased. After cessation of immobilization intervals, tyrosine hydroxylase levels decreased toward preimmobilization levels with a half-life of about 3 days.

SOURCE: Endocrinology 87: 744-750, 1970

AUTHOR(S): Kvetnansky, R., G.P. Gewirtz, V.K. Weise, and I.J. Kopin

EXPERIMENT TITLE: Effect of Dibutyryl Cyclic-AMP on Adrenal Catecholamine-Synthesizing Enzymes in Repeatedly Immobilized Hypophysectomized Rats

SUBJECTS: Male Sprague-Dawley rats (200-220 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Two days after hypophysectomy, rats were administered 25 mg sc in 0.25 ml 8% gelatin dibutyryl cyclic-AMP twice daily or 5 IU sc ACTH daily. For rats immobilized daily for 2.5 hr, drugs were given 30-60 min before each immobilization. Animals were immobilized by inserting their heads through 2 metal loops and taping their limbs to metal mounts attached to a board. Drug treatment and/or immobilization were repeated for 6 days. Rats were killed by cervical fracture 8 days after hypophysectomy, 6 hr after last immobilization, and 9 hr after drug administration; adrenals were removed.

IMMOBILIZATION METHOD: Metal loops, metal mounts, tape, and board

RESULTS: In hypophysectomized and repeatedly immobilized hypophysectomized rats the administration of dibutyryl cyclic-AMP or ACTH resulted in marked increases in adrenal tyrosine hydroxylase (TH) and dopamine- β -hydroxylase, and a small but significant increase in phenylethanolamine-N-methyl transferase levels, paralleling the increase in adrenal weight. Levels of adrenal TH in immobilized hypophysectomized rats treated with dibutyryl cyclic-AMP were not greater than levels in untreated controls. ACTH treatment restored elevated levels of TH produced by immobilization in normal rats.

SOURCE: Endocrinology 89: 50-55, 1971

AUTHOR(S): Kvetnansky, R., G.P. Gewirtz, V.K. Weise, and I.J. Kopin

EXPERIMENT TITLE: Enhanced Synthesis of Adrenal Dopamine β -Hydroxylase
Induced by Repeated Immobilization in Rats

SUBJECTS: Male Sprague-Dawley rats (180-250 gm)

DISCIPLINE(S): Endocrine

OBJECTIVES: In title

PROTOCOL: Rats were immobilized in a prone position daily for periods up to 2.5 hr by inserting their heads through 2 parallel concentric steel wire loops fixed on a metal plate and fastening their limbs with adhesive tape to 4 metal strips. Rats were decapitated immediately after the immobilization interval or 6 or 24 hr after their release; in one experiment, rats were killed either 24 hr after the end of the 6th immobilization period or 0.5, 1.0, or 2.5 hr after the start of the 7th immobilization; one group was killed 6 hr after the end of the seventh 2.5-hr immobilization period. Adrenal glands were removed. In some experiments 20 mg/kg hexamethonium was given ip 30 min before restraint to prevent catecholamine release; in others, 1 mg/kg actinomycin D was given sc 15 min pre- and 2 hr post-immobilization to inhibit adrenal protein synthesis. The effect of adrenal denervation was studied. Measurements: dopamine β -hydroxylase.

IMMOBILIZATION METHOD: Wire loops, metal strips, tape, and metal plate

RESULTS: Repeated restraint resulted in striking increases in adrenal medullary dopamine β -hydroxylase activity. After 6 restraint periods, the levels were highest preceding the next restraint, decreased during the restraint, and increased upon restraint termination. 6 hr post-restraint activities returned almost to prerestraint levels. Adrenal denervation markedly diminished the increase in dopamine β -hydroxylase activity that occurred with repeated restraint. Prior treatment with hexamethonium prevented the decrease in activity during the restraint interval, whereas the protein synthesis inhibitors actinomycin D and cycloheximide prevented the increase in enzyme activity seen after the end of restraint.

SOURCE: Molecular Pharmacology 7: 81-86, 1971

AUTHOR(S): Kvetnansky, R., S. Silbergeld, V.K. Weise, and I.J. Kopin

EXPERIMENT TITLE: Effects of Restraint on Rat Adrenomedullary Response to 2-Deoxy-D-Glucose

SUBJECTS: Male Sprague-Dawley rats (180-250 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Rats were immobilized in a prone position for 2.5 hr daily for 7 or 40 days by inserting their heads through 2 concentric steel wire loops fixed on a metal plate and fastening their limbs with adhesive tape to 4 metal strips. Urine was collected for 2 consecutive 24-hour intervals at the beginning of the last immobilization period. 4 days later rats were injected with 500 µg/kg 2-deoxy-D-glucose (2DG), then urines were collected for 2 consecutive 24-hr intervals. To evaluate adrenal gland changes, rats were immobilized for 1 or 7 days. Other groups received 2DG in 1.0 ml water sc; some were immobilized daily and given 2DG after each restraint period once or 7 times. All rats were decapitated 6 hr after last 2DG injection. Measurements: urine; norepinephrine; epinephrine; adrenal gland. Diet: 5% sucrose solution during first 2 days of urine collection, then food and water ad libitum for 4 days; only water was given ad libitum on the day 2DG was administered.

IMMOBILIZATION METHOD: Wire loops, metal strips, tape, and metal plate

RESULTS: 24-hr urinary epinephrine (E) of the initial period was markedly increased after 7 and 40 immobilizations. The E increase was significant during the 2nd day of collection after 7 immobilizations but not after 40. E levels for all rats were increased during 2DG administration, a greater increase after 40 immobilizations than after 7. Adrenal changes: 6 hr after 1 immobilization followed by 2DG, adrenal E was markedly lowered and adrenal tyrosine hydroxylase (TH) and phenylethanolamine-N-methyl transferase were slightly increased. Rats immobilized and treated daily with 2DG for one wk showed markedly lowered adrenal E and increased TH and dopamine-β-hydroxylase.

SOURCE: Psychopharmacologia 20(1): 22-31, 1971

AUTHOR(S): Kvetnansky, R., V.K. Weise, G.P. Gewirtz, and I.J. Kopin

EXPERIMENT TITLE: Synthesis of Adrenal Catecholamines in Rats During and After Immobilization Stress

SUBJECTS: Male Sprague-Dawley rats (180-220 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Rats were immobilized daily for 2.5 hr for 1, 7 or 40 days. Animals were immobilized by inserting their heads through 2 metal loops and taping their limbs to metal mounts attached to a board. Uniformly labeled L-tyrosine-¹⁴C and dopa-³H were given iv either 1.5 hr after beginning of last immobilization or 24 hr after last immobilization. Rats were decapitated 1 hr after injection of radioactive compounds, adrenals were removed. Measurements: adrenal norepinephrine, dopamine, catecholamines; tyrosine in blood plasma.

IMMOBILIZATION METHOD: Metal loops, metal mounts, tape, and board

RESULTS: Increased enzyme levels resulted in enhanced synthesis of epinephrine-¹⁴C from tyrosine-¹⁴C but not from dopa-³H. During immobilization, conversion of tyrosine-¹⁴C to catecholamines was increased further and may exceed the capacity of dopamine- β -hydroxylase to convert dopamine to norepinephrine.

SOURCE: Endocrinology 89: 46-49, 1971

AUTHOR(S): Kvetnansky, R., I.J. Kopin and J.M. Saavedra

EXPERIMENT TITLE: Changes in Epinephrine in Individual Hypothalamic Nuclei after Immobilization Stress

SUBJECTS: Sprague-Dawley rats (200-250 gm)

AREA OF STUDY: Endocrine; Nervous

OBJECTIVES: In title

PROTOCOL: Rats were immobilized in a prone position for 20 or 240 min by inserting their heads through 2 parallel concentric steel wire loops fixed on a metal plate and fastening their limbs with adhesive tape to 4 metal strips. Immobilized and control animals were decapitated, and brain hypothalamic areas and nuclei were dissected. Measurements: epinephrine concentration.

IMMOBILIZATION METHOD: Wire loops, metal strips, tape, and metal plate

RESULTS: After 20 or 240 min of immobilization, there were no significant changes in epinephrine concentrations in the nucleus supraopticus, nucleus paraventricularis and dorsomedial nucleus. After 20 min of immobilization, a small but significant increase in epinephrine levels in the median eminence, and a decrease in epinephrine in the nucleus hypothalamicus anterior, were the only changes noted. More pronounced changes were detected after 240 min of immobilization, with more than a 50% decrease in epinephrine levels in the nucleus periventricularis and nucleus hypothalamicus anterior, and significant decreases in the nucleus ventromedialis and nucleus arcuatus.

SOURCE: Brain Research 155(2): 387-390, 1978

AUTHOR(S): Labie, C., H. LeBars, and J. Tournut

EXPERIMENT TITLE: Lesions of the Digestive System Determined by Forced Immobilization in Pigs

SUBJECTS: 29 Pigs (20-35 kg)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: All pigs were immobilized for 24 hr suspended in corsets with extremities free. Each was given 400 to 600 ml of tyrode solution during this period to make up for the hydrochlorinated losses. The survivors were sacrificed by bleeding following anesthesia. Measurements: gastric lesions; histology of pancreas and suprarenals.

IMMOBILIZATION METHOD: Corset

RESULTS: All of the pigs developed gastric lesions of various degrees and 80% developed ulcers of the fundus mucous type. All cases showed a considerable degree of sanguine stasis. The chromaffin cells of the medullo-suprarenal were in state of degranulation, and the pancreas showed lesions of intense ischemic necrosis.

SOURCE: Comptes Rendus des Seances de la Societe de Biologie et de ses Filiales 160: 675-677, 1966

AUTHOR(S): Lahtiharju, A. and T. Rytomaa

EXPERIMENT TITLE: DNA Synthesis in Fore and Glandular Stomach and in Skin After Nonspecific Stress in Mice

SUBJECTS: Male white mice

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental mice were deprived of food but not water for 21 hr then immobilized for 5 hr in gauze softened window screen, then allowed free access to food and freedom of activity. Mice were killed by ether 1 hr or 1, 2 or 3 days after immobilization. Each mouse received 2 $\mu\text{C/gm}$ of Schwarz's ^3H -thymidine 1 hr prior to killing. Specimens were taken from the fore and glandular stomach and the skin, sectioned, and autoradiograms were prepared.

IMMOBILIZATION METHOD: Gauze softened window screen

RESULTS: Labelling indices, expressed in relation to the corresponding control mean, decreased by some 70% in all organs studied. The glandular stomach recovered from stress more slowly than the fore stomach and epidermis.

SOURCE: Experimental Cell Research 46: 593-596, 1967

AUTHOR(S): Lambert, R., M.S. Martin, and F. Martin

EXPERIMENT TITLE: Gastric Ulcers in Rats Caused by Restraint in a Metal Tube

SUBJECTS: Wistar rats, 61 male, 43 female (150-200 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 61 hypokinetic males; 2) 43 hypokinetic females. Rats were immobilized in metal tubes for 24 hr without the use of anesthesia. Five sizes of tubes were used depending on the size of the rat (from 40-48 mm internal diameter). The tubes were pierced with holes for ventilation and closed with flexible lids. Each tube was placed on wedges in a box 30 x 15 x 20 cm. Measurements: ulcers.

IMMOBILIZATION METHOD: Metal tube

RESULTS: Of 104 rats, 74 developed ulcers (71%); 31 of 61 males developed ulcers (62%), and 36 of 43 females developed ulcers (84%). Females showed a greater susceptibility to ulcers from immobilization.

SOURCE: Comptes Rendus des Seances de la Societe de Biologie et de ses Filiales 161: 816-818, 1967

AUTHOR(S): Lambert, R., C. Andre, and F. Martin

EXPERIMENT TITLE: Incorporation of Radiosulfate in the Gastric Mucosa
of the Rat Subjected to Restraint

SUBJECTS: Male Wistar rats (185-195 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) restraint - 22 rats, restraint induced by means of a metal tube, 24 hr duration; 2) controls. Each animal received an ip injection of carrier-free sulfur³⁵ as sodium sulfate in water. At the end of 24 hr the animals were killed, the stomachs were removed and divided into mucosa and muscular layer. After homogenization, each fraction was digested by pepsin for 24 hr. The nondialyzable radiosulfate was divided into two fractions, precipitated and nonprecipitated as cetylpyridinium complex. Measurements: ulceration; dialyzable and nondialyzable radiosulfate activity; fractions precipitable or nonprecipitable by CPC.

IMMOBILIZATION METHOD: Metal tube

RESULTS: Ulceration: none of the controls showed any gastric ulcers; 13 of the 22 restrained rats showed evidence of gastric ulcers. Dialyzable radiosulfate constituted 32% of total radiosulfate in the mucosa of the controls, 40% in ulcerated restrained rats, and 34% in rats without ulcers; no significant variation between the three groups. Nondialyzable radiosulfate was lower in rats with ulcers after restraint (60.2% of controls), but did not vary significantly between controls and non-ulcerated restrained rats. Similar results were obtained for the fractions precipitated or not precipitated by CPC: in the ulcerated, restrained animals the first fraction reached 64.1% of controls, the second reached 57.8% of controls; in restrained, non-ulcerated rats the first fraction reached 87.2% of controls, the second reached 98.4% of controls (not significant).

SOURCE: Gastroenterology 56(2): 200-205, 1969

AUTHOR(S): Lambert, R., C. Andre, M.S. Martin, and F. Martin

EXPERIMENT TITLE: Uptake of Radioactive Sulfate by the Tissues of Normal Rats under Restraint

SUBJECTS: Female Wistar rats, 3 mo old (150 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) restrained in metallic tubes. The rats received an ip injection of 100 μCi ^{35}S , in the form of radiosulfate without a carrier. The rats were sacrificed after 24 hr, and the radioactivity of various tissues was measured.

IMMOBILIZATION METHOD: Tube

RESULTS: In the rat under restraint, the concentration of radiosulfate in the digestive tissues varied considerably. There was a significant fall in the stomach with values 58 per 100 and 65 per 100 of normal in the fundus and antrum respectively. This fall was not noted in any other segment of the digestive tract. There was a rise in radioactivity in the proximal part of the intestine (duodenum and jejunum) and in various other tissues (ears, tail, trachea); the other tissues showed no significant variations.

SOURCE: Archives Francaises des Maladies de l'Appareil Digestif 58(6): 35-44, 1969

AUTHOR(S): Lamprecht, F., R. Kvetnansky, L.K.Y. Ng, R.B. Williams, and I.J. Kopin

EXPERIMENT TITLE: Effect of Δ^9 -Tetrahydrocannabinol on Immobilization-Induced Changes in Rat Adrenal Medullary Enzymes

SUBJECTS: Male adult Sprague-Dawley rats (200 gm)

AREA OF STUDY: Endocrine; Pharmacology

OBJECTIVES: In title

PROTOCOL: Two experiments: 1) rats were immobilized 2-hr daily for 7 consecutive days; 1 hr prior to each immobilization period, groups of 6-8 rats (immobilized, nonimmobilized) received 20 mg/kg sc Δ^9 -tetrahydrocannabinol (Δ^9 -THC) in .1 ml ethanol or ethanol alone; another group of controls received .1 ml saline; 2) immobilized and nonimmobilized rats received either chlorpromazine 10 mg/kg in 2 ml saline po, phenobarbital 20 mg/kg ip, lithium 1.5 meq/kg in 2 ml saline po, or meprobamate 150 mg/kg in 1 ml 65% polyethylene glycol ip prior to immobilization; other controls received only vehicle solutions ip or po. Following day 7 immobilization, rats were killed by cervical dislocation and adrenals were removed rapidly. Measurements: adrenal enzyme activity (tyrosine hydroxylase, dopamine- β -hydroxylase, dopa decarboxylase, phenylethanolamine-N-methyltransferase).

IMMOBILIZATION METHOD: Not stated

RESULTS: Immobilization-induced increases in tyrosine hydroxylase and dopamine- β -hydroxylase was markedly enhanced by Δ^9 -THC; neither ethanol alone nor ethanol plus Δ^9 -THC altered enzyme levels in nonimmobilized controls.

SOURCE: European Journal of Pharmacology 21: 249-251, 1973

AUTHOR(S): Lamprecht, F., R.B. Williams, and I.J. Kopin

EXPERIMENT TITLE: Serum Dopamine-Beta-Hydroxylase During Development of Immobilization-Induced Hypertension

SUBJECTS: Male Sprague-Dawley rats (140-160 gm)

AREA OF STUDY: Circulatory; Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats were subjected to repeated immobilization for 2-hr periods daily for 4 wk (total = 28 periods). Blood pressure was determined prior to, at various intervals during, and at weekly intervals following immobilization. In some rats, blood pressure was determined before and during ether anesthesia. Measurements: blood pressure; serum dopamine-beta-hydroxylase (DBH).

IMMOBILIZATION METHOD: Not stated

RESULTS: Both serum DBH and blood pressure increased significantly after 2 wk of repeated immobilization. Differences between blood pressure in experimental and control rats remained the same under anesthesia. After wk 4 of immobilization, serum DBH and blood pressure increased further. Serum DBH returned to normal postimmobilization, but blood pressure remained elevated for 2 additional wk.

SOURCE: Endocrinology 92: 953-956, 1973

AUTHOR(S): Landry, M. and H. Fleisch

EXPERIMENT TITLE: The Influence of Immobilisation on Bone Formation
As Evaluated by Osseous Incorporation of Tetracyclines

SUBJECTS: 70 Inbred male and female albino rats (110 or 210 gm)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 31 younger (110 gm); 2) 39 older (210 gm). One hind limb immobilized by either section of the ligamentum patellae and tendo calcaneus or section of the 2nd, 3rd and 4th lumbar nerve trunks. Contralateral limbs served as the control. Group 1 was given 15 mg/kg ip chlortetracycline daily for 5 days. Group 2 was given the same dose every other day for 10 days. The last injection was given 48 hr prior to sacrifice. Rats were killed 12, 28 and 49 days and 5 mo after operations. Measurements: body weight; bone weight; tetracycline uptake.

IMMOBILIZATION METHOD: Denervation; Tenotomy

RESULTS: The length of the femora and tibiae did not show a significant difference between the normal and the immobilized side. In all animals the weight of the immobilized bones decreased progressively until the 49th day. The absolute amount of tetracycline incorporated showed a decrease after 12 days; later it increased but never reached the level of normal bone. Only after prolonged immobilization did the tetracycline uptake drop to subnormal values. Immobilization was effective for about 2 wk. Afterwards the tendons repaired by scar tissue and function was partly restored. Weight decreased only in the first experimental period of 12 days and later increased again. Tetracycline incorporation, following an initial fall, showed a marked increase after 28 days, when expressed either as an absolute value or per unit of bone weight.

SOURCE: Journal of Bone and Joint Surgery 46B(4): 764-771, 1964

AUTHOR(S): Lapenkova, I.Z.

EXPERIMENT TITLE: Effects of Gravitational Stress and Hypokinesia
on the Structure of Blood Vessels of the Rabbit
Tongue

SUBJECTS: 120 Rabbits

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Hypergravitational stress (rotation on centrifuge of 1 m radius) and/or hypokinesia (cages). Five groups: 1) single maximum permissible gravitational stress in the cranio-caudal, caudal-cranial, or ventrodorsal directions; 2) 1-12 wk hypokinesia; 3) stress and subsequent 4-12 wk hypokinesia; 4) successively applied stress, 4 wk hypokinesia, and repeated stress; 5) similar to (4), but applied to animals first subjected to conditioning to the stress effects by exposure to gradually increasing stresses. Studies were made on specially prepared slices. Measurements: morphological changes in the circulatory vessels of the tongue.

IMMOBILIZATION METHOD: Cage (close)

RESULTS: Gravitational stress caused dilation of the vessels in the capillary-venous part of the circulatory bed. Hypokinesia produced morphological changes most pronounced in the terminal portions of the arterial part of the bed, arterioles, and precapillaries. Preliminary conditioning to stresses failed to prevent the appearance of considerable morphological changes in the tongue blood vessels. Successive action of the two factors did not result in any characteristic morphological changes inherent only to such combined effect.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 69(10): 55-61, 1975

AUTHOR(S): Leise, E.M., T.N. Morita, I. Gray, and F. Lesane

EXPERIMENT TITLE: Lymphocyte and Polymorphonuclear Enzymes in Stress.
II. Effect of the Stress of Restraint on Rabbit
Leukocyte Protein, Aldolase, and Lactate Dehydro-
genases

SUBJECTS: Rabbits

AREA OF STUDY: Blood; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) restrained in the supine position for 4 or 6 hr. Rabbits were bled before and immediately after being restrained; they were bled again 24 hr after 0-time bleeding. Control rabbits were subjected only to the stress of repeat bleeding. Measurements: leukocyte lactate dehydrogenase (LDH); isoenzymes; protein; aldolase.

IMMOBILIZATION METHOD: Not stated

RESULTS: Increased polymorphonuclear (PMN) enzymes after restraint was shown in increased cells of the heaviest density layer. Lymphocytes from the top layer showed increments in protein and LDH but not in aldolase following 4-6 hr restraint. There was no change in lower layer lymphocytes. Restraint caused a greater increase in LDH of PMN from the bottom gradient than in PMN from the gradient above it; protein changes were not parallel. Protein, aldolase, and LDH were increased in the mixed population of cells from gradient layer 3 immediately after restraint. There were some enzyme and protein changes in leukocytes 24-hr poststress. There were some differences in the quantitative distribution of LDH isoenzymes in repeatedly bled and restrained rabbits.

SOURCE: Biochemical Medicine 4: 336-346, 1970

AUTHOR(S): Lenskaya, G.N.

EXPERIMENT TITLE: Blood Supply to the Skeletal Muscles of Rats During Hypokinesia

SUBJECTS: White rats (230-400 gm)

AREA OF STUDY: Muscular; Circulatory

OBJECTIVES: In title

PROTOCOL: Hypokinesia was created by placing the animals in individual cages (7 x 7 x 15 cm) for 5, 15 and 30 days. The control animals were kept under ordinary vivarium conditions. On termination of hypokinesia quantitative changes in capillary blood flow were studied in vivo in m. semimembranosus and m. soleus using intravascular injections of India ink and gelatin mixtures. Blood flow was determined with respect to the number of capillaries per unit area and per one muscle fiber as well as with respect to the total surface of capillaries from the total surface of muscle fibers.

IMMOBILIZATION METHOD: Cage (7 x 7 x 15 cm)

RESULTS: M. semimembranosus exhibited a significant increase in the mean radius of the muscle fibers and capillaries. Due to considerable weight losses during the early hypokinetic stages the relative number of capillaries per unit area increased. M. soleus exhibited a significant decrease in the number of capillaries per unit area (by 14-16%) and per muscle fiber.

SOURCE: Space Biology and Medicine 7(4): 17-22, 1972

AUTHOR(S): Levine, R.J. and E.C. Senay

EXPERIMENT TITLE: Histamine in the Pathogenesis of Stress Ulcers in the Rat

SUBJECTS: Female CD rats (180-220 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Immobilization and cold restraint. Three groups: 1) subjects were immobilized in a rigid plastic device and refrigerated at 4-7°C for 2-3 hr; 2) restraint at room temperature for 14 hr; 3) controls. Some subjects were pretreated with brocresine (ip injection 3 hr before stress) or aminoguanidine (ip injection 30 min before stress). Animals were killed by decapitation, and stomachs were removed for examination. Measurements: histamine, histidine decarboxylase activity; number of lesions.

IMMOBILIZATION METHOD: Plastic device

RESULTS: There was no consistent change in histamine level in the gastric mucosa. Histidine decarboxylase activity in gastric mucosa increased significantly in association with stress; the degree of increase correlated positively with the number and severity of lesions observed. Immobilization plus cold exposure for 2 hr was more effective than simple physical restraint for 14 hr. Pretreatment with brocresine resulted in a significant decrease in the number and severity of lesions. Pretreatment with aminoguanidine resulted in a significant increase in the number of lesions observed.

SOURCE: American Journal of Physiology 214: 892-896, 1968

AUTHOR(S): Levites, Z.P. and V.F. Fedotova

EXPERIMENT TITLE: Effect of Prolonged Hypokinesia on Tissue Blood Flow

SUBJECTS: Rabbits (1930-2380 gm)

AREA OF STUDY: Circulatory; Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) rabbits immobilized for 90 days in small cages. Measurements: the tissue blood flow in the femoral muscle assessed by the resorption of Na-I¹³¹ injected into the tissue; and erythrocyte count.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: Hypokinesia for 90 days slowed the tissue blood flow. There was an increase in the dimensions of erythrocytes.

SOURCE: Eksperimentalnaia Khirurgiia i Anesteziologiia 3: 79-80,
May/June 1974

AUTHOR(S): Li, S.Ye. and O.I. Kirillov

EXPERIMENT TITLE: Cell Changes in Rat Livers During Hypokinesia

SUBJECTS: Male Wistar rats (95-100 gm)

AREA OF STUDY: Digestive; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental rats placed in tight cages. 5 to 9 rats from the experimental and control groups were killed 12 hours, 2, 5, 9, 14 and 19 days after onset of the experiment. Measurements: nuclear size, mitotic index and number of binucleate cells in the liver; body weight and liver weight.

IMMOBILIZATION METHOD: Cage

RESULTS: In rats kept for 19 days under hypokinetic conditions there was a well-expressed lag in the weight increment. The absolute weight of the liver decreased whereas its relative weight increased. Nuclear ploidy decreased, the mitotic index declined and the number of binucleate cells more than doubled. It was assumed that some polyploid cells were transformed into binucleate cells which in turn divided into mononuclear diploid cells.

SOURCE: Space Biology and Aerospace Medicine 8(2): 16, 1974

AUTHOR(S): Lidbrink, P., H. Corrodi, K. Fuxe, and L. Olson

EXPERIMENT TITLE: Barbiturates and Meprobamate: Decreases in Catecholamine Turnover of Central Dopamine and Noradrenaline Neuronal Systems and the Influence of Immobilization Stress

SUBJECTS: Male albino Sprague-Dawley rats (150-200 gm)

AREA OF STUDY: Nervous; Pharmacology

OBJECTIVES: In title

PROTOCOL: Two groups: 1) stressed; and 2) nonstressed. The stressed group was immobilized for 4 hr by being wrapped in metal nets. The effect of phenobarbitone 100 mg/kg ip combined with H44/68 250 mg/kg ip on central noradrenaline (NA) and dopamine (DA) levels was biochemically analyzed. Histochemical studies comprised meprobamate and 3 barbiturates (phenobarbitone, pentymalum, and pentobarbitone), each given ip 30 min prior to H44/68; rats were decapitated under chloroform anesthesia 4 hr later. Diet: commercial food pellets; water ad libitum. Measurements: DA; NA; monoamine oxidase (MAO) activity.

IMMOBILIZATION METHOD: Metal net

RESULTS: Barbiturates, but not meprobamate, clearly decreased NA turnover in the cortical NA nerve terminals. No clear effects were found in the hypothalamus with the 2 drugs. Stress increased NA turnover in all parts of the brain studied; these increases could be counteracted by both barbiturates and meprobamate. DA turnover in the nerve terminals of the neostriatum and the median eminence was reduced after 4 hr stress. The stress-induced decrease in turnover of the DA terminals in the neostriatum was further decreased by pretreatment with barbiturates or meprobamate; these drugs accelerated DA turnover in the external layer. Phenobarbitone did not affect MAO activity in the cerebral cortex, neostriatum, or hypothalamus when compared with H44/68-treated controls, though all groups were lower than untreated controls.

SOURCE: Brain Research 45: 507-524, 1972

AUTHOR(S): Linc, R. and J. Fleischmann

EXPERIMENT TITLE: Histochemical Profile of Soleus Muscle in Rat in Different Conditions

SUBJECTS: Male rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Rats were divided at the 30th day of life into 3 groups with the following conditions: 1) standard laboratory conditions; 2) hyperkinesia, rats were forced to run on a treadmill at a speed of 20 m/min for 3 hr daily; 3) hypokinesia, rats were enclosed in narrow boxes. All subjects were killed on the 115th day of life, and the soleus muscle was removed and prepared. Measurements: fibre type of soleus muscle.

IMMOBILIZATION METHOD: Box (narrow)

RESULTS: There were no significant changes in the muscle fibre type picture of hyper- and hypokinetic rats.

SOURCE: Folia Morphologica 25(2): 140-143, 1977

AUTHOR(S): Lindenbaum, E.S. and J.J. Mueller

EXPERIMENT TITLE: Effects of Pyridoxine on Mice After Immobilization Stress

SUBJECTS: 70 Female albino CF-1 mice, 3-6 wk old (16.5-31.3 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Five groups: 1) controls; 2) 1.11 mcg/gm B₆, 24-hr restraint, and killed; 3) B₆, 24-hr restraint, and killed 24-hr postrestraint; 4) distilled water injection, 24-hr restraint, and killed immediately postrestraint; and 5) distilled water injection, 24-hr restraint, and killed 24-hr postrestraint. Measurements: glucose in blood; N-methylnicotinamide in urine; norepinephrine in brain; serotonin in brain.

IMMOBILIZATION METHOD: Cage

RESULTS: Pyridoxine (B₆) groups had increased blood glucose levels, urinary N-methylnicotinamide, and brain norepinephrine; brain serotonin levels were unchanged. B₆ was protective against ulcers of the stomach mucosa.

SOURCE: Nutrition and Metabolism 17: 368-374, 1974

AUTHOR(S): Lindgren, J.U.

EXPERIMENT TITLE: Studies of the Calcium Accretion Rate of Bone During Immobilization in Intact and Thyroparathyroidectomized Adult Rats

SUBJECTS: 153 Male Sprague-Dawley rats

AREA OF STUDY: Skeletal; Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 81 thyroparathyroidectomized rats (524.1 gm); 2) 72 rats (454.5 gm). Each group was then divided into two subgroups: a) immobilized by fixing the rats in a simple device and applying a strip of polyvinyl wool around the pelvis and the right hind leg which was then fixed between two layers of elastic adhesive bandages; b) controls. Immobilization of rats from group 1 started 3 days after thyroparathyroidectomy. Groups of 8 rats each were immobilized for 1, 2, 4, 8, 12 and 16 wk. Groups of control non-immobilized animals, 23 thyroparathyroidectomized and 24 intact rats, were observed in groups of 3 or 4 also for 1 to 16 wk. Isotope (^{45}Ca) was injected ip 72 hr before killing the rats. After killing, the femora and the tibiae of both hind legs were thoroughly dissected free. Blood was collected at 6, 24 and 48 hr after isotope injection and when killing the rats. Measurements: calcium accretion rates; ^{45}Ca activity; bone mass.

IMMOBILIZATION METHOD: Polyvinyl wool and elastic adhesive bandages

RESULTS: Disuse osteoporosis occurred in the virtual absence of the thyroid and parathyroid glands. Bone loss of the immobilized femur and tibia was less marked in thyroparathyroidectomized rats vs. intact rats. ^{45}Ca uptake in immobilized compared with non-immobilized bone increased to the same proportion in thyroparathyroidectomized and intact rats. Calcium-accretion rates of immobilized bones were lower in thyroparathyroidectomized than in intact rats.

SOURCE: Calcified Tissue Research 22: 41-47, 1976

AUTHOR(S): Lipman, R.L., P. Raskin, T. Love, J. Triebwasser, F.R. Lecocq, and J.J. Schnure

EXPERIMENT TITLE: Glucose Intolerance During Decreased Physical Activity in Man

SUBJECTS: 15 Male rhesus (Macaca mulatta) monkeys (3.4-6.8 kg)

AREA OF STUDY: Digestive; Metabolism and Energy Exchange

OBJECTIVES: Studied human subjects also.

PROTOCOL: Two groups: 1) 10 controls; 2) 5 immobilized monkeys. All monkeys underwent 3 days of carbohydrate loading of 50 gm/day glucose. Group 2 monkeys were immobilized in full body casts (vertical position) for 2-16 wk. Studies and results for humans subjected to bedrest are also reported. Diet: standard monkey chow ad libitum. Measurements: intravenous glucose tolerance; body weight.

IMMOBILIZATION METHOD: Cast

RESULTS: There was no change in body weight. The mean glucose disappearance rate (Kg) was significantly less than in normal monkeys.

SOURCE: Diabetes 21(2): 101-107, 1972

AUTHOR(S): Lippmann, R.K. and S. Selig

EXPERIMENT TITLE: An Experimental Study of Muscle Atrophy

SUBJECTS: 118 Rabbits

AREA OF STUDY: Muscular

OBJECTIVES: To determine the relative speed, extent and mechanism of acute, secondary muscle atrophy, especially of the arthrogenic type.

PROTOCOL: Four groups of experiments; the semitendinosus muscle was used for the first 3 groups, the gastrocnemius muscle for the 4th: 1) technique of experimental arthritis: 40 rabbits, turpentine injected hypodermatically as irritant (0.75 cc-0.2 cc), 1-17 days duration; 2) technique of nerve section: 20 rabbits, one-half inch incision made in direction of fibers of gluteus maximus muscle, fibers of gluteus maximus and medius were separated by blunt dissection and retracted, exposing sciatic nerve; 2-50 days duration; 3) technique of tenotomy: 25 rabbits; the tendon of the semitendinosus was brought into a wound made by a vertical incision in the inner side of the leg; 2-35 days duration; 4) technique of immobilization: 15 rabbits; application of plaster spica from mid-thoracic region to the toes; 4-32 days duration. Measurement: wet and dry muscle weight.

IMMOBILIZATION METHOD: Plaster spica; Tenotomy; Denervation

RESULTS: The atrophies that followed nerve section, tenotomy and arthritis were rapid in onset (measurable after 48 hr), with almost equally brisk progression in all forms; that which followed immobilization was small in degree and slow in onset (not appreciable before lapse of at least a month).

SOURCE: Surgery, Gynecology and Obstetrics 47: 513-522, 1928

AUTHOR(S): Lobachik, V.I. and B.B. Yegorov

EXPERIMENT TITLE: Calcium Metabolism During Hypokinesia (Experimental Investigation)

SUBJECTS: 250 Male white rats (180-200 gm)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinetic in cages (root of the animal's tail was fastened) for 30 and 60 days. At the end of these periods, the rats were injected ip with 0.05 mc/kg isotope; they were decapitated 0.5, 1, 3, 6, 12, 24 hr and 2.5 and 10 days later. Measurements: incorporation, distribution, and release of Ca^{45} in the epiphysis and diaphysis of the femur, the lower incisors, the alveolar processes of the lower jaw, the cervical vertebrae, and the parietal bones.

IMMOBILIZATION METHOD: Cage

RESULTS: Incorporation of Ca^{45} in the epiphysis and diaphysis of the femur, the cervical vertebrae, and parietal bones was less in experimental rats than in the controls. The differences in isotope accumulation in the alveolar processes of the lower jaw in the experimental and control animals were slight. For the incisors, the amount of isotope accumulated was markedly higher in the experimental animals than in the control group.

SOURCE: Eksperimental'nye Issledovaniya Gipokinezii, Izmenennoi Gazovoi Sredy, Uskorenii, Peregruzok i Drugikh Faktorov (ed. by V.V. Parin et al), 1968, pp. 15-17.

AUTHOR(S): Lobova, T.M.

EXPERIMENT TITLE: Blood and Tissue Lipids in Hypodynamic Rats

SUBJECTS: 97 White male rats (180-200 gm)

AREA OF STUDY: Blood; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental. The experimental animals were placed in special small-volume cages which restricted their mobility. The duration of hypodynamia was 1, 3, 15, 30 and 60 days. The animals were killed by decapitation. Measurements: cholesterol content; total lipids; β -lipoproteins.

IMMOBILIZATION METHOD: Cage (small-volume)

RESULTS: Hypodynamic exposure was followed by an increase in the level of cholesterol and β -lipoproteins in the serum. The cholesterol content in tissues, especially in the skeletal muscles, increased. The total quantity of lipids in the skeletal muscles, liver, and to a lesser extent, in the heart, decreased.

SOURCE: Space Biology and Medicine 7(5): 45-50, 1973

AUTHOR(S): Lobova, T.M. and A.V. Chernyy

EXPERIMENT TITLE: Effect of Physical Loads on Some Parameters of Lipid and Carbohydrate Metabolism During Hypokinesia

SUBJECTS: 140 Male rats (150-230 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Four groups: 1) unrestricted regimen, subjects maintained in ordinary vivarium cages; 2) unrestricted regimen with measured physical exercise (swimming); 3) restricted mobility, subjects maintained in small cages; 4) restricted mobility combined with swimming. The animals were decapitated on the 15th, 30th, 60th and 90th experimental days. Measurements: blood, liver and skeletal muscle cholesterol; nonesterified fatty acids (NEFA); ketone bodies; total lipids; glycogen; lipolytic activity of fatty tissue.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: Rats kept under hypokinetic conditions showed a significant decrease of glycogen content in the liver and skeletal muscles, acceleration of lipolysis in the adipose tissue, progressive increase of the content of NEFA, ketone bodies and cholesterol in the blood, decrease of the content of total lipids and increase of the cholesterol content in the skeletal muscles and liver. Hypokinetic rats exposed to exercise exhibited changes in carbohydrate and lipid metabolism; the content of ketone bodies in the blood increased a little, the glycogen content in tissues decreased to a lesser extent, the cholesterol level in the blood and skeletal muscles increased only on the 15th day, remained at the control level at later stages and even decreased in the skeletal muscles.

SOURCE: Space Biology and Medicine 11(6): 45-51, 1977

AUTHOR(S): Loginova, Ye.V., A.I. Volozhin, I.G. Krasnykh, Ye.A. Stroganova

EXPERIMENT TITLE: Oxygen Consumption of Animals Under Conditions of Hypokinesia

SUBJECTS: 350 White rats (150-270 gm); 2 dogs, 1½-2 yr old; and 8 squirrels

AREA OF STUDY: Metabolism and Energy Exchange; Respiratory

OBJECTIVES: In title

PROTOCOL: Five groups: 1) control rats, subgroups for effects of differences in weight, sex, and time of year; 2) rats hypokinetic in close fitting cages for 10, 15, 20, 30, 40 and 60 days, either 150-230 gm (young), or 250-270 gm (old); 3) 2 dogs hypokinetic for 6 mo, tested at 0, 10, 20, 40 days, 2, 3, 4, 5 and 6 mo; 4) control squirrels with exercise wheel; 5) squirrels in cage with no exercise wheel. Measurements: oxygen consumption for 15 min at intervals stated.

IMMOBILIZATION METHOD: Rats and dogs: cage (close fitting); squirrels: cage (35 x 35 x 40 cm)

RESULTS: There was no difference in oxygen consumption between the sexes. Younger rats consumed more oxygen than older ones, and oxygen consumption was highest in September-October, and lowest in March-April. Hypokinetic rats consumed oxygen increasingly up to 15 days, then dropped to control level after 20 to 30 days, then increased sharply from 40-100 days. In hypokinetic dogs, oxygen consumption decreased greatly (35-43%) by the 20-30th days, then tended to increase to initial or higher levels. The oxygen consumption of squirrels kept in cages without the exercise wheel was considerably lower than the controls.

SOURCE: Patologicheskaiia Fiziologiia i Eksperimentalnaia Terapiia No.4: 32-36, 1975

AUTHOR(S): Lubeyev, A.G.

EXPERIMENT TITLE: The Effect of Hypodynamia and Hypokinesia and Subsequent Hypergravitation on the Blood Vessels of the Capsule of the Rabbits's Knee Joint

SUBJECTS: Male rabbits (2-2.5 kg)

AREA OF STUDY: Musculoskeletal; Circulatory

OBJECTIVES: In title

PROTOCOL: A plaster cast was applied to the right hind leg of 26 rabbits in the flexed position for durations from 3 weeks to 7 months. Three of the rabbits immobilized for 2.5 mo and 3 immobilized for 5.5 mo were exposed to individual intolerable G forces of 9.6 units in the craniocaudal direction. The arterial system was injected with India ink and the vessels were counted. Measurements: diameter of the vessels of the knee joint capsule.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: One to 2 wk after immobilization, the animals developed a myogenic stage of contracture. Dilatation of capillaries, elongation and increased quantity per field was observed. Desmogenous contracture began to develop after 3 to 4 wk of immobilization. From 1.5 mo of immobilization on, the desmogenous phase of contracture was demonstrable. The arthroogenous stage of contracture was observed in 5.5-7 mo immobilization with a decrease in quantity of vessels and anastomoses. As the term of immobilization increased, the range of joint movement decreased.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii No.11: 109-115, December 1970

AUTHOR(S): Ludwig, W.M. and M. Lipkin

EXPERIMENT TITLE: Biochemical and Cytological Alterations in Gastric Mucosa of Guinea Pigs Under Restraint Stress

SUBJECTS: 130 Adult white male guinea pigs (300-350 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: All guinea pigs were maintained in individual wire bottom cages at a constant temperature of 76°F and were given food and water ad libitum until the start of the experimental conditions. Three groups: 1) control; 2) fasted for 24 hr and then killed; 3) restrained. Restrained guinea pigs were taken from their cages and were immobilized in an envelope of window screen in individual boxes with wood shavings for periods of 1.5 to 40 hr. Animals released after a 24-hr period of restraint were returned to the wire bottom cages and allowed free access to food and water. At the completion of a treatment period, individual animals were injected ip with either thymidine-methyl-³H or uridine-5-³H. Animals were then killed with ether, and the excised stomach and duodenum were opened and examined for erosions. Measurements: number, severity and distribution of lesions; number of mast cells; gastric juice acid; mucosal mucus content; incorporation of thymidine-³H into DNA or uridine-5-³H in RNA.

IMMOBILIZATION METHOD: Window screen and individual box

RESULTS: The number of animals developing stress erosions increased progressively in time and reached 90% in 40 hr. During the development of the erosions, some animals developed many lesions, while others developed none. Immobilization caused rapid degranulation of the mast cells of the gastric mucosa. However, there was no correlation between the reduction in mast cells and the occurrence of erosions in individual animals. Acid concentration and volume of gastric juice in the stomach at the time of sacrifice were not significantly different among restrained animals with and without lesions or in fasted controls. Decrease in periodic acid-Schiff positive mucosubstances in surface cells of the gastric mucosa appeared to be present after 18 hr of stress. This occurred together with a progressive decrease in DNA synthesis during stress and a loss of RNA from the gastric tissue.

SOURCE: Gastroenterology 56(5): 895-902, 1969

AUTHOR(S): Luparello, T.J.

EXPERIMENT TITLE: Restraint and Hypothalamic Lesions in the Production of Gastroduodenal Erosions in the Guinea Pig

SUBJECTS: 122 Hartley strain male guinea pigs (330-400 gm)

AREA OF STUDY: Digestive; Nervous

OBJECTIVES: In title

PROTOCOL: Six groups: 1) restraint only, 22 subjects, prior 24 hr fast, immobilized with wire screen; 2) anterior hypothalamic lesions made by passing an anodal current through electrodes, 20 subjects; 3) posterior hypothalamic lesions, 20 subjects; 4) anterior hypothalamic lesions and subsequent 24 hr restraint, 20 subjects; 5) posterior hypothalamic lesions and subsequent 24 hr restraint, 21 subjects; 6) thalamic lesions (electrodes implanted in dorsal thalamus) and subsequent 24 hr restraint, 19 subjects. Diet: Purina guinea pig chow and tap water ad libitum prior to the experiment. Measurements: gastroduodenal erosions.

IMMOBILIZATION METHOD: Wire screen

RESULTS: Gastrointestinal erosions were induced in the guinea pig by restraint (41%), anterior hypothalamic lesions (35%), posterior hypothalamic lesions (45%), and by combined lesions and restraint (47-71%). The number of erosions varied from 1 to 7 per animal. The greatest incidence of erosions occurred in group 5.

SOURCE: Journal of Psychosomatic Research 10: 251-254, 1966

AUTHOR(S): Macho, L., M. Palkovic, L. Mikulaj, and R. Kvetnansky

EXPERIMENT TITLE: Tissue Metabolism in Rats Adapted to Immobilization Stress

SUBJECTS: Male Wistar rats (170-190 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Immobilization periods, 150 min - 4 groups: 1) immobilized once; 2) immobilized 10 times; 3) immobilized 40 times; 4) controls. The rats were decapitated; the left lobe of the liver with the heart and the muscle from the anterior abdominal wall were removed, and homogenized. Measurements: oxidation of glucose, pyruvate, α -ketoglutarate and succinate.

IMMOBILIZATION METHOD: Not stated

RESULTS: The rate of oxidation of all substrates, except glucose, was decreased in the liver and skeletal muscle of rats immobilized once or 10 times. After 40 immobilization periods, adaptation took place, the rates of oxidation were the same as in the controls. In cardiac muscle the oxidation of substrates was increased in animals immobilized once or 10 times but was closer to normal in those adapted to this stress.

SOURCE: Physiologia Bohemoslovaca 17(2): 173-178, 1968

AUTHOR(S): Macho, L., M. Alexandrova, M. Hromadova, V. Strbak, and R. Kvetnansky

EXPERIMENT TITLE: Response of the Adrenals to Stress in Animals from Litters with Different Numbers of Young

SUBJECTS: Infant Wistar rats

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Newborn rats were adjusted in litters as follows: 1) overfed, 4 per liter; 2) control, 8 per liter; 3) underfed, 14 per liter. Two series of experiments: I, Laparotomy: rats in this series were weaned at 30 days, separated according to sex and placed in cages in groups of 6. After weaning they were allowed food ad libitum. The overfed and underfed groups were exposed to stress by laparotomy under anaesthesia at ages 30 and 180-190 days. After 15 min, rats were killed and blood was taken and adrenals removed. Series II, Immobilization - rats were allowed to age to 300-360 days. Overfed and underfed rats were then subjected to immobilization stress by inserting their heads through 2 metal loops and taping their limbs to metal mounts attached to a board either once for 30 min or for 2.5 hr daily for 7 days and 30 min on the day of the experiment. Rats were then killed, blood was taken and adrenals were removed. Measurements: plasma corticosterone level; adrenal corticosterone production.

IMMOBILIZATION METHOD: Metal loops, tape and board

RESULTS: Adrenal and plasma corticosterone levels decreased the most in overfed female rats at age 30 and 180 days. When subjected to stress by laparotomy at these ages, adrenal corticosterone production and plasma corticosterone levels increased greatly. There were significant differences between over and underfed groups in plasma corticosterone level after stress, but no significant differences among the groups in adrenal corticosterone production after laparotomy stress. After immobilization stress at 300-360 days old, overfed rats had a lower plasma corticosterone concentration than underfed animals, the difference was most pronounced in females. Adrenal corticosterone production and the plasma level rose significantly after immobilization stress, the rise being greater in overfed females. The only significant differences in males were in the increased in corticosterone production after a single immobilization.

SOURCE: Physiologia Bohemoslovaca 24(6): 501-508, 1975

AUTHOR(S): Mack, P.B., R.A. Hoffman, and A.N. Al-Shawi

EXPERIMENT TITLE: Physiologic and Metabolic Changes in Macaca nemestrina
on Two Types of Diets During Restraint and Non-restraint:
II. Bone Density Changes

SUBJECTS: Macaca nemestrina monkeys (7.4-8.4 kg)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Four groups: 1) control, non-restrained and Diet A; 2) restrained and Diet A; 3) non-restrained and Diet B; 4) restrained and Diet B. The 'restrained' primates were strapped in couches (a hammock of nylon net strung in a rectangular aluminum frame) for 35 days with a subsequent exposure to a Biosatellite simulated reentry profile with centrifugation to 12-G, followed by a 35-day period of post-restraint on the same diet. The non-restrained groups remained in metabolism cages except on the 35th day when they also were exposed to the reentry profile. Diet B was superior in all nutrients (except protein) for which analyses were made; Diet B had three times as much calcium and almost one and one-half times as much phosphorus as Diet A. The two diets were similar in provision of energy. Bone mass changes were determined by radiographic bone densitometry.

IMMOBILIZATION METHOD: Couch

RESULTS: Bone density was significantly improved in most of 17 skeletal sites when given Diet B. Restraint resulted in skeletal mass loss under both diets. Diet B had a greater effect on improving bone density during the reconditioning period than during restraint.

SOURCE: Aerospace Medicine 39: 698-704, 1968

AUTHOR(S): Magladery, J.W. and D.Y. Solandt

EXPERIMENT TITLE: Relation of Fibrillation to Acetylcholine and Potassium Sensitivity in Denervated Skeletal Muscle

SUBJECTS: Albino rats (200-350 gm)

AREA OF STUDY: Muscular

OBJECTIVES: A consideration of acetylcholine and potassium antagonism relative to the effect of quinidine on fibrillation

PROTOCOL: The gastrocnemius-soleus muscle was denervated by removing a length of the sciatic nerve (0.5 cm). Amplification of the action potentials - process: tendon dissected out, lower limb then immobilized with metal clamps running from rigid uprights to the femur and foot, cord from a small hook through the muscle tendon attached to an isotonic lever writing on a smoked drum, action potentials were led from the muscle belly and amplified. Injections were then made: acetylcholine bromide (29 rats) - 0.002γ to 2 mg; potassium chloride (12 rats) - 0.2, 2.0 and 20 mg per cc; quinidine - 25 mg per cc. All agents (drugs in aqueous solution) were injected intraarterially (lower aorta) in constant volumes (0.25 cc) at constant rates. Diet: adequate. Measurements: mechanical and electrical responses of the muscle to acetylcholine and potassium, before and after quinidine administration.

IMMOBILIZATION METHOD: Metal clasps and denervation

RESULTS: Acetylcholine-quinidine: intraarterially injected acetylcholine produced characteristic action potentials of fibrillation in a 2 phase response. The duration of the second phase (prolonged slower mechanical movement during which all action potentials were abolished) varied with dosage and, with the smallest doses, was absent or transient. Quinidine produced an immediate cessation of fibrillation in all cases; the action potentials were abolished, with no evident mechanical movement of the muscles. Responses to higher levels of acetylcholine were opposed to a less degree with time. Potassium-quinidine: intraarterially injected potassium produced action potentials comparable to those of fibrillation; less difference between sensitivities of normal and denervated muscle to potassium. Similar trend as per acetylcholine, although results less clear: sensitivity to potassium after quinidine declined relative to size of dosage; e.g., doses of 2 mg or less were ineffective, while higher concentrations of potassium showed more variation.

SOURCE: Journal of Neurophysiology 5: 357-362, 1942

AUTHOR(S): Maier, A., E. Eldred, and V.R. Edgerton

EXPERIMENT TITLE: The Effects on Spindles of Muscle Atrophy and Hypertrophy

SUBJECTS: 27 Adult cats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Medial gastrocnemius muscle. Three groups: 1) immobilization - 14 cats, cast from toe to midhigh, various periods 14-71 days; bipolar 200 μ m stainless steel wire electrodes were threaded through the bellies of the muscle; 2) synergist-denervated - 10 cats, extra loading of medial gastrocnemius attained by cutting the nerve supplying the lateral gastrocnemius, soleus, and plantaris muscles, exposure and manipulation of same structures done in contralateral leg; 3) controls. Animals were given freedom of the laboratory several times a week. For terminal observations on afferent activity, tracheal and intravenous cannulae were inserted under pentobarbital anesthesia; laminectomy. To record whole dorsal root activity, the S₁ roots were placed over bipolar silver electrodes. Measurements: fiber areas; changes in twitch/tetanic maximum tension; discharge rates of afferent units at different degrees of sustained muscle stretch; changes in pulse rate per increment of gross muscle stretch.

IMMOBILIZATION METHOD: Plaster cast; Denervation

RESULTS: The cross-sectional areas of both nuclear bag and chain IF fibers were found to be reduced in the immobilized muscles and increased in the synergists-denervated series relative to the areas in contralateral muscles. Proportionately, the changes in IF fibers were less than those found among extrafusal fibers. In the immobilized series the bilateral difference in bag fiber areas was greater than that of the chronic fibers, while among extrafusal fibers slow-twitch fibers were affected more than fast-twitch fibers. The discharge of spindle units monitored from dorsal root filaments at resting muscle length was elevated in the immobilized muscles, as was also the stretch sensitivity, i.e., increase in pulse rate per increment of gross muscle stretch. In muscles of the synergist -denervated series, the background discharge was increased also, but the effect on stretch sensitivity was not clearly defined.

SOURCE: Experimental Neurology 37: 100-123, 1972

AUTHOR(S): Maier, A., J.L. Crockett, D.R. Simpson, C.W. Saubert IV, and V.R. Edgerton

EXPERIMENT TITLE: Properties of Immobilized Guinea Pig Hindlimb Muscles

SUBJECTS: 16 Adult guinea pigs (420-650 gm)

AREA OF STUDY: Muscular

OBJECTIVES: Contractile, biochemical, histochemical and morphological evaluations

PROTOCOL: Immobilization of the soleus and gastrocnemius muscles of 16 guinea pigs by inserting sterile 22-gauge hypodermic needles diagonally into the tibia and femur, and longitudinally through the tarsal bones and shaft of the tibia. The approximate angle of fixation for the knee was 70°, and for the ankle 90°. Contralateral limbs remained unrestrained. After 4 wk, 10 animals whose pinned knee and ankle joints were either rigidly fixed or allowed no more than 5° of motion were anesthetized with chloral hydrate (400 mg/kg) and recorded. Animals were then killed, and a 3-4 mm long section was removed from the midlength of the muscles for histochemical preparations and glycogen determination. Diet: Purina guinea pig chow; water. Measurements: time-to-peak tension, twitch tension, tetanic tension, twitch fatigue, muscle weight, protein fractionation, glycogen content.

IMMOBILIZATION METHOD: Internal fixation with needles

RESULTS: Average time-to-peak tension of the immobilized soleus was decreased by 30%, whereas that of the gastrocnemius was not significantly changed relative to the contralateral muscles. Immobilized soleus muscles acquired as much as 25% fibers with high alkaline myofibrillar adenosine triphosphatase activity; these fibers do not occur in normal muscle. Neither the immobilized soleus nor gastrocnemius fatigued more quickly than their contralateral counterparts. In the immobilized gastrocnemius, myofibrillar protein decreased to 76% and maximum tetanic tension to 70% of contralateral values. Tetanic tension per gm wet muscle weight or 100 mg myofibrillar protein was significantly greater in the immobilized gastrocnemius.

SOURCE: American Journal of Physiology 231: 1520-1526, 1976

AUTHOR(S): Makarov, G.A.

EXPERIMENT TITLE: Effect of Hyperbaric Oxygenation on Carbohydrate Metabolism and Protein Synthesis in the Myocardium During Sustained Hypodynamia

SUBJECTS: 140 Male albino rats (170-240 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypodynamia in close individual cages that restricted mobility in all directions for 45 days. In the last 2 days of hypodynamia, both groups were placed in a decompression chamber for 3 hr with pure oxygen under pressure at 1.5 atmospheres. After this exposure, the rats were kept under normal conditions for 3 hr then killed, and the heart excised. Six hr prior to death, all animals were injected ip with 25 μ /100 gm glycine- C^{14} . Heart tissue underwent histochemical analysis. Measurements: intensity of glycolysis from levels of glycogen, pyruvate, lactate; activity of enzymes of glycolysis from levels of aldolase and lactate dehydrogenase (LDH); intensity of protein synthesis by rate of inclusion of glycine- C^{14} .

IMMOBILIZATION METHOD: Cage (close individual)

RESULTS: Prolonged immobilization induced an increase in the amount of lactic (53.6%) and pyruvic (17.6%) acids, lactate/pyruvate coefficient, activities of aldolase (56%) and lactate dehydrogenase (25.5%), exhaustion of glycogen supplies (56.7%) and reduction in intensity of protein synthesis in subcellular fractions of the myocardium. Hyperbaric oxygenation increased the oxidation of pyruvate and intensity of synthetic processes in the myocardium, which led to a reduction in the concentration of pyruvate and lactate in the blood and myocardium of animals with hypodynamia.

SOURCE: Kardiologiia 14(2): 73-77, 1974

AUTHOR(S): Makarov, G.A.

EXPERIMENT TITLE: Mechanism of Disorder of Plastic Processes in Tissue During Prolonged Hypokinesia

SUBJECTS: Male rats (170-240 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Four groups: 1) controls, untreated or injected with retabolil or ergocalciferol; 2) hypodynamic in immobilization chambers for 15, 30 and 45 days; 3) hypodynamic for 45 days and injected with retabolil or ergocalciferol; 4) hypodynamic for 34 days and injected with retabolil and ergocalciferol. Retabolil (1 mg/kg im) was administered twice, at 7 and 14 days before death, and vitamin D (ergocalciferol 100 ME ia) was administered daily for the last 7 days before death. 6 hr prior to death, all animals were injected ip with 25 μ C/100 gm glycine-1-C¹⁴; after death the myocardium, skeletal muscles, liver, and kidneys were excised. Measurements: intensity of the protein synthesis in the mitochondria and post-mitochondrial supernatant by level of glycine-1-C¹⁴.

IMMOBILIZATION METHOD: Chamber

RESULTS: In the 2nd wk of hypokinesia there was an inhibition of the synthesis processes. Administration of retabolil increased protein synthesis in the control and hypokinetic animals, however, in the latter group synthesis did not normalize especially in the myocardium. Administration of vitamin D also stimulated protein synthesis. The combined action of both preparations was the most effective in normalizing protein synthesis intensity.

SOURCE: Patologicheskaya Fiziologiya i Eksperimentalnaya Terapiya No. 4: 41-45, 1974

AUTHOR(S): Marcondes de Souza, J.P., F.F. Machade, A. Sesso, and V. Valeri

EXPERIMENT TITLE: Experimental Joint Immobilization in Guinea Pigs
Effects on the Knee Joint

SUBJECTS: 87 Juvenile guinea pigs (310-520 gm) and adult (760-950 gm)

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Four groups: 1) 12 juvenile controls killed at 3, 4 and 5 mo of age; 2) 34 juvenile immobilized, killed at 1, 2, 3, 4, 5, 6, 7, 8 and 9 wk after start of immobilization; 3) 6 adult controls killed at 15, 16 and 17 mo of age; 4) 35 adult immobilized, killed at 1, 2, 3, 4, 5, 6, 7, 8 and 9 wk after start of immobilization. Plaster casts were applied while a forced position of the coxofemoral joints and extension of the knee joints was maintained. The knee joints were excised, inspected, then cross-sectional slices were prepared for microscope examination.'

IMMOBILIZATION METHOD: Plaster cast

RESULTS: Muscular hypotrophy and joint stiffness occurred in all animals, and increased with length of immobilization. Haemoarthrosis occurred in the 1st wk. Intrajoint adhesions occurred after 3 to 4 wk and became more numerous. Only in adults did the adhesions reach the level of real fibrous ankylosis. Hyaline articular cartilage erosion occurred in both juveniles and adults. Degenerative lesions of the meniscus were found only in adults. Osteoporosis of the fibular and tibial epiphyses occurred only in adults. Pathologies were generally more numerous and pronounced in the adults.

SOURCE: Revista da Associacao Medica Brasileira 10(7): 159-175, 1964

AUTHOR(S): Marin, B., A. Menendez-Patterson, and J.A. Florez-Lozano

EXPERIMENT TITLE: Oxidative Metabolism of Different Structures of the Central Nervous System and Its Correlation With Gastric Ulcers by Immobilization

SUBJECTS: Male Wistar rats (280±19.9 gm)

AREA OF STUDY: Digestive; Nervous

OBJECTIVES: In title

PROTOCOL: Three groups fasted for 24 hr: 1) immobilization stress with pain from peripheral oedema and necrosis in the parts of the leg tied with wire; 2) same method except the wires were replaced with adhesive tape, thus eliminating pain; 3) control - isolated for 24 hr. Measurements: oxidative metabolism of amygdala, frontal cortex, hypothalamus, adrenal; gastric ulcers; adrenal weight.

IMMOBILIZATION METHOD: Four hole metallic net and wire or tape

RESULTS: Both food deprivation and immobilization caused stomach ulceration. The oxygen uptake was higher in animals under painless immobilization; the number of ulcers was greater under painful immobilization. There were significant adrenal weight differences in both experimental groups as compared to controls; painless stress caused an increase, painful stress a decrease in weight.

SOURCE: Indian Journal of Medical Research 66(5): 852-858, 1977

AUTHOR(S): Markova, O.O., A.S. Vavryshchuk, V.I. Rozvodovs'kyi, and V.A. Proshcheruk

EXPERIMENT TITLE: Influence of Experimental Hypokinesia on Gastric Secretory Function

SUBJECTS: White rats (150-220 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Five groups: 1-4) immobilized for 4, 8, 16 and 30 days respectively; 5) control. 18 days before immobilization, the rats were fasted with water ad libitum. Rats were immobilized in metal cages with individual sections. During immobilization a ligature between the duodenum and pylorus was made and remained in the animal for a period of 2 days. The amount of gastric juice was measured during the 2 day tie-off. The acidity of the gastric juice (total, free, and bound) was determined microchemically. At the end of the 2 day period the stomach was removed, washed in physiological saline and dried. Diet: bread and milk.

IMMOBILIZATION METHOD: Cage (metal)

RESULTS: Inhibition of both the gastric secretory and acid producing functions was found during hypokinesia. The greatest inhibition was found on day 8 of immobilization when the gastric secretion decreased by 55% and the total acidity decreased by 59%.

SOURCE: Fiziologicheskii Zhurnal 23(5): 653-656, 1977

AUTHOR(S): Marsh, J.T. and A.F. Rasmussen, Jr.

EXPERIMENT TITLE: Response of Adrenals, Thymus, Spleen and Leucocytes to Shuttle Box and Confinement Stress

SUBJECTS: Female Swiss mice (4-6 wk old)

AREA OF STUDY: Endocrine; Blood

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls; 2) confinement (physical restraint); 3) shuttle box. Mice were subjected to the stressors for 6 hr/day, 6 days/wk and sacrificed after varying intervals of stress exposure (1-28 days) and periods of recovery. Measurements: organ weights; total and differential leucocyte counts in tail blood.

IMMOBILIZATION METHOD: Not stated

RESULTS: Changes in organ weights and leucocytes following daily stress was observed. Adrenal hypertrophy and drop in circulating leucocytes were relatively rapid with significant changes observed following 3 to 7 days of stress. Involution of thymus and spleen occurred more slowly with maximum differences seen after 14 to 28 days of stress. Differences between experimental and control values returned to non-significant levels in 21 days after the termination of stress.

SOURCE: Proceedings of the Society for Experimental Biology and Medicine 104: 180-183, 1960

AUTHOR(S): Martin, M.S., F. Martin, and R. Lambert

EXPERIMENT TITLE: Effect of Habituation on the Susceptibility of the Rat to Restraint Ulcers

SUBJECTS: 30 Wistar rats (200-270 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 4 sessions of restraint in metal tubes for 6 hr each over a period of 2-4 wk with an interval of 3-15 days between restraints. 3 days after the 4th session, the rats were subjected to restraint for 24 hr; 2) controls subjected to the 24-hr period of restraint at the same time as group 1. Measurement: ulcerous lesions.

IMMOBILIZATION METHOD: Metal tube

RESULTS: The frequency and gravity of restraint ulcers were significantly diminished in group 1 rats previously exposed to immobilizations of short duration.

SOURCE: Comptes Rendus des Sciences de la Societe de Biologie et de ses Filiales 164(4): 826-828, 1970

AUTHOR(S): Martin, M.S., F. Martin, and R. Lambert

EXPERIMENT TITLE: The Effect of Ambient Temperature on Restraint Ulcer
in the Rat

SUBJECTS: 48 Female Wistar rats

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: The animals were bred in a laboratory at a controlled temperature of 25°C. After a 24-hr fast, the rats were restrained in metal tubes for 24 hr. The surrounding temperature was controlled by placing the tubes in an oven located in a cold room. The animals were divided into 4 groups of 12 each and restrained respectively at 19°, 22°, 25° and 28°C. At the end of the 24-hr restraint period the rectal temperature of the rat was registered. Then the animal was killed with ether and the stomach was opened and checked for ulcerations. Measurements: rectal temperature; incidence of ulcerations.

IMMOBILIZATION METHOD: Metal tube

RESULTS: The frequency of gastric lesions in each temperature group was 100%(19°C), 67%(22°C), 17%(25°C) and 25%(28°C). The mean rectal temperature for groups restrained at 22°, 25° and 28°C demonstrated no significant variations. But, the rectal temperature was significantly lower in the groups restrained at 19°C.

SOURCE: Digestion 3: 331-337, 1970

AUTHOR(S): Mason, J.W.

EXPERIMENT TITLE: Corticosteroid Response to Chair Restraint in the Monkey

SUBJECTS: 15 Adult male rhesus (Macaca mulatta) monkeys (4-7.2 kg)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Prerestraint period, 3 mo - two groups: 1) 7 monkeys housed in individual cages in a large colony of monkeys; 2) 8 monkeys housed in individual metabolic cages in the same experimental cubicle in which all were eventually to be placed in the restraining chair. All monkeys were restrained in chairs for 6 day/wk over an 8-wk period. Diet: Dietrich and Gambrill monkey biscuits, apples, carrots, whole wheat bread, 400 ml/day water. Measurements: urinary 17-hydroxycorticosteroid (17-OHCS).

IMMOBILIZATION METHOD: Chair

RESULTS: Mean urinary 17-OHCS levels were elevated 3-fold during the first 3 days of chair restraint. Duration of response varied between different monkeys and in relation to prerestraint housing conditions. There were no chronic effects of chair restraint on the pituitary-adrenal cortical system.

SOURCE: American Journal of Physiology 222: 1291-1294, 1972

AUTHOR(S): Mason, J.W. and E.H. Mougey

EXPERIMENT TITLE: Thyroid (Plasma BEI) Response to Chair Restraint
in the Monkey

SUBJECTS: 26 Adult male rhesus (Macaca mulatta) monkeys (4-7.2 kg)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Prerestraint period, 3 mo - two groups: 1) 16 monkeys housed in individual cages among a large colony of monkeys; 2) 10 monkeys housed in individual metabolic cages in the same experimental cubicle in which all were eventually to be placed in the restraining chair. All monkeys were restrained in chairs for 6-day periods over 8-10 wk. Diet: Dietrich and Gambrill monkey biscuits, apples, carrots, whole wheat bread, 400 ml/day water. Measurements: hormone analysis; plasma butanol extractable iodine (BEI).

IMMOBILIZATION METHOD: Chair

RESULTS: BEI levels were elevated through 6 days restraint. By day 3, BEI increased from 3.2 to 5.1 $\mu\text{g}\%$ peak. For 14 monkeys over an 8-wk restraint period, response duration varied, but mean BEI levels remained significantly elevated through the 3rd wk. Restabilized BEI levels during the 2nd mo of restraint did not differ significantly from levels in the same monkeys when they were housed in a prerestraint low-density chamber.

SOURCE: Psychosomatic Medicine 34(5): 441-448, 1972

AUTHOR(S): Mason, J.W., E.H. Mougey, and C.C. Kenion

EXPERIMENT TITLE: Urinary Epinephrine and Norepinephrine Responses
to Chair Restraint in the Monkey

SUBJECTS: 14 Adult male rhesus monkeys (4-7.2 kg)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Prerestraint period, 3 mo - two groups: 1) 6 monkeys housed during the prerestraint period in a room with a large colony of monkeys; 2) 8 monkeys, housed during prerestraint in metabolic cages in the same experimental cubicle in which all were eventually to be placed in the restraining chair. All monkeys were subjected to 8 wk of chair restraint inside a sound resistant, dimly lighted booth, temperature averaging 75°F. Urine collection in group 1 began as soon as the monkeys were placed in the restraining chair. In group 2, weekly urine pools were collected prior to restraint. During restraint, urine collection was the same for both groups. Urine was collected and frozen until biochemical analysis was performed. Measurements: urinary epinephrine and norepinephrine.

IMMOBILIZATION METHOD: Chair

RESULTS: Mean urinary epinephrine levels showed a greater than three-fold increase in monkeys during the first 3 days of chair restraint remaining significantly elevated through the first week of restraint and the initial response was significantly higher in group 1 than in group 2. The mean urinary norepinephrine level ran higher in group 1 than in group 2 but in general, these changes were less marked than the epinephrine changes.

SOURCE: Physiology and Behavior 10(4): 801-804, 1973

AUTHOR(S): Mateeff, D., D. Yonkov, M. Hristova, L. Cheresharov,
S. Toshkova, and R. Radomirov

EXPERIMENT TITLE: On Certain Physiological and Morphological Changes
in Immobilized and Training Albino Rats

SUBJECTS: Male Wistar albino rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls; 2) functionally loaded; 3) immobilized. The functionally loaded animals were trained on a tread-course every day (6 days/wk) for 10 min in the beginning with an increase of 10 min every 10 days of training, reaching a total of 50 min at the end of the experiment. A total of 90 ± 8 trainings were carried out at 550 m/h. Animals were immobilized by placing them in individual cells. At the end of the experiment the animals were killed using ether. Diet: water and tablet food ad libitum. Measurements: body weight; weight of bones; weight of internal organs; glycogen and neutral lipid content.

IMMOBILIZATION METHOD: Cell

RESULTS: The entire body specific weight was highest in the training group and the lowest in the immobilized group. The average relative weight of the bones was appreciably lower in the immobilized animals than in the trained control groups. The highest relative weight of the investigated organs was found in the trained animals; organ weight in the immobilized animals was appreciably lower. Group 1 demonstrated a change in the skeletal muscle of a hypertrophic character, with a well expressed glycogen content. The immobilized group showed symptoms of atrophy, and a decreased glycogen content. The histological structure of the liver in the animals of the two groups did not differ from that of the controls. There were no differences among the 3 groups in the amount and localization of neutral lipids in the organs investigated.

SOURCE: Izvestiia na Instituta po Fiziologiya 13: 131-138, 1970

AUTHOR(S): Mateeff, D., N. Bodourov, K. Binev, D. Yonkov, L. Cheresharov, R. Radomirov, and S. Toshkova

EXPERIMENT TITLE: Certain Changes in the Skeleton of Immobilized and Training Albino Rats

SUBJECTS: 28 Albino rats

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls; 2) immobilized; 3) trained. Rats were immobilized by placing them in individual round cells. The trained rats were exercised a total of 90 times on an endless belt of a tread-course moving at a speed of 550 m/h with a progressive increase in the loading from 10 to 50 min. Roentgenography was used to investigate the dynamics of bone formation and bone-destruction processes. Diet: food and water ad libitum.

IMMOBILIZATION METHOD: Cell

RESULTS: Group 3 showed a markedly greater compactness and better developed structural form in all skeletal bones. Immobilization of the animals led to the development of osseotrophic states. The compactness and structural shape of bone from the control group was on an intermediate level, being closer to that of the immobilized animals.

SOURCE: Izvestiia na Instituta po Fiziologiya 13: 139-144, 1970

AUTHOR(S): Mateeff, D., Y. Tsacheva, D. Yonkov, S. Toshkova,
L. Cheresharov, and R. Radomirov

EXPERIMENT TITLE: Regeneration Capacities of the Skin in Trained and
Immobilized Albino Rats

SUBJECTS: Male albino Wistar rats

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls; 2) immobilized; 3) training, functional loading with physical work. Wounds were made following epilation of the back; the animals lived under the above conditions until the wounds healed. The investigation was carried out in 2 experiments. In the 1st (21 rats, 17 mo old), ellipsoid wounds were made; in the 2nd (30 rats, 7 mo), round wounds were made. Measurements: surface of healing wounds; histological investigation.

IMMOBILIZATION METHOD: Not stated

RESULTS: Immobilization resulted in a relative delay in the healing of the wound surface. The histological investigation established a delay and irregularity in the differentiation of the granulation tissue and in the formation of the cicatrice of the immobilized rats. There was also a drop in the rate of keratin formation in the regenerated epidermis. Training led to a more rapid decrease in the surface of the wounds made, compared with the control and immobilized rats; this trend was observed up to the 9th day. The percentage of the earliest healed wounds was the highest in the trained animals.

SOURCE: Izvestiia na Instituta po Fiziologiya 13: 145-152, 1970

AUTHOR(S): Mateeff, D., L. Cheresarov, D. Yonkov, R. Radomirov,
and S. Toshkova

EXPERIMENT TITLE: Effect of Increased and Diminished Functional Loading
With Physical Work on the Reproductive Function of Rats:
Physical Work, Hypodynamics and Reproduction

SUBJECTS: 150 Male and female Wistar rats

AREA OF STUDY: Reproduction

OBJECTIVES: In title

PROTOCOL: Three groups of 10 males and 40 females: 1) functionally loaded - exercised by running on a treadmill with increased loading over 95 days; 2) immobilized in individual circular wire mesh cages for 108 days; 3) unrestrained controls. When the rats were 6 1/2 mo old (108 days from the beginning of the experiment), 30 colonies were formed, 1 male to 4 females, making the following 9 combinations: trained male with trained females; trained male with control females; trained male with immobilized females; immobilized male with immobilized females; immobilized male with control females; immobilized male with trained females; control male with control females; control male with trained females; control male with immobilized females. The animals were kept in colonies for 7 days, each colony in a separate cage. Diet: normal with vitamins and trace elements. Measurements: fertility; mortality of progeny.

IMMOBILIZATION METHOD: Cage (circular, wire mesh, 16 cm diameter, 11 cm high on solid base)

RESULTS: The trained animals were in the best, and the immobilized in the poorest breeding condition. Immobilized male and female animals in homogeneous colonies had the lowest fertility, in heterogeneous colonies with control or trained partners, they showed a high degree of fertility. The active animal of either sex succeeded in activating and impregnating its inactive partner. The highest mortality of the progeny was observed in colonies of immobilized animals; the lowest in colonies which included exercising animals.

SOURCE: Journal of Reproduction and Fertility 24(3): 337-344, 1971

AUTHOR(S): Mateeff, D.M., S.H. Milanov, G.I. Dashev, D.I. Yonkov,
and U.G. Tsacheva

EXPERIMENT TITLE: Changes in the Pituitary-Thyroid and in the Pituitary-
Gonad Systems Under Conditions of Functional Loading
and of Physiological Immobilization

SUBJECTS: Male Wistar rats, average age 245 days

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Three groups: 1) systematically loaded by running on a
treadcourse, 8 rats for 90 days, 8 for 180 days; 2) rats were immobilized
in small cells for 90 days, 8 for 180 days; 3) 16 controls. Excretion
of gonadotropins (GTH) was determined from 24 hr urine collection by
injecting extracted GTH into infantile female mice which caused a
growth of the uterus and tubes; GTH excretion was expressed as the
weight of the tubes and uterus in mg. The animals were sacrificed
and the plasma concentration of thyrotropic hormone (TTH) was determined.
The pituitaries, thyroids and testes were examined histologically.

IMMOBILIZATION METHOD: Cell (small)

RESULTS: The total 24-hr excretion of GTH was 11.8 mg in the animals
treated for 90 days and 13.3 mg in animals trained for 180 days.
Animals immobilized for 90 days showed a decline in the growth of the
uterus and tubes (6.2 mg); this decline was more marked in animals
immobilized for 180 days (4.5 mg). Histological examinations of the
thyroid gland of the animals in the training group revealed the colloid
matter in the lumen of the follicles showed a trend toward decrease as
well as PAS-positive matters. The pituitaries of these animals showed
an increase of the granulated structures in the basophil cells secreting
hormones. In immobilized animals, the thyroid was smaller in size and
a decrease of the granulated structures of the basophil cells secreting
GTH and TTH was observed in the pituitary. An increase in the number
of differentiated forms of spermatogenesis was seen in the testes of
training rats while in the immobilized rats there was a decrease in
differentiated cells.

SOURCE: Comptes Rendus de l'Academie Bulgare des Sciences 25(7):
995-998, 1972

AUTHOR(S): Mateeff, D., St. Milanov, G. Dashev, D. Yonkov, and I. Zacheva

EXPERIMENT TITLE: Influence of Functional Loading and Physiological Immobilization on Some Endocrine Glands

SUBJECTS: Male albino Wistar rats (245 days old)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Three groups: 1) trained through running on a treadmill (90 or 180 days); 2) immobilized in cages for 90 or 180 days; 3) control. Animals were then killed and samples for morphological studies were taken from the hypophysis, thyroid and testes. Measurements: plasma concentration of thyrotropic hormone; 24-hr gonadotropic hormone excretion; neutral and acid mucopolysaccharides; differentiation of separate cells in the hypophysis.

IMMOBILIZATION METHOD: Cage

RESULTS: Strenuous physical exercise increased thyrotropic and gonadotropic hormone excretion and activity of the thyroid and testes; restraint had the opposite effect.

SOURCE: Aggressologie 13(2): 121-125, 1972

AUTHOR(S): Mateeff, D. and N. Georgieva

EXPERIMENT TITLE: Certain Changes in the Higher Nervous Activity of Functionally Loaded and Immobilized 10-Month-Old Albino Rats

SUBJECTS: 12 Female albino Wistar rats

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Three groups of 4 rats each: 1) treadmill training with gradual loading, 180 training exercises; 2) immobilized in cages for 6 mo; and 3) control. Diet: tablet food; water ad libitum. Measurements: higher nervous activity (motor-defense conditioned reflexes).

IMMOBILIZATION METHOD: Cage

RESULTS: Functional loading had a favorable effect on the basic nervous processes in the cerebral cortex. In trained rats the percentage of positive conditioned reactions (CRs) to a metronome (120 strokes/min) and to light (75 W), and the percentage of the negative motor-defense reactions to a metronome (60 strokes/min) and light (15 W) were considerably superior to the same indices in the controls and especially in the restrained rats. In trained rats there was a statistically significant shortening of the CRs' durations and latencies. Functional restraint reduced the percentage of the positive and negative CRs, and prolongation of CRs' duration and latencies.

SOURCE: Acta Physiologica et Pharmacologica Bulgarica 2: 37-45, 1974

AUTHOR(S): Matlina, E.Sh., S.M. Waysman, I.G. Zaydner, B.M. Kogan, and L.V. Nozdracheva

EXPERIMENT TITLE: Effect of Consecutive Cooling and Immobilization on Catecholamine Metabolism in Rat Tissues

SUBJECTS: Male rats (150-200 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Four groups: 1) subjected to cooling for 8 hr at -7°C , then immobilized for 6 hr in a special stand with the body and limbs clamped. Rats were administered 1-DOPA ip (45 mg/kg) prior to cooling, prior to immobilization; 2) same as group 1, except that a physiological saline solution was administered instead of 1-DOPA; 3) cooled for 8 hr, administered physiological saline solution prior to cooling; and 1.5 hr before end of immobilization; 4) immobilized for 6 hr, administered physiological saline solution prior to and 1.5 hr before the end of immobilization. The animals were decapitated and adrenal glands, heart and hypothalamus were excised. Measurements: adrenaline, noradrenaline and DOPA; microscopic changes.

IMMOBILIZATION METHOD: Stand with clamps

RESULTS: Cooling and immobilization together with DOPA administration induced a decrease in adrenaline, noradrenaline and DOPA content in the adrenal glands. In the heart, hypothalamus and blood there were no significant shifts. Immobilization alone caused a decrease in adrenaline and DOPA, and an increase in noradrenaline. 24 hr after cooling only, no changes in catecholamine content in the adrenal glands were found. In group 2 (controls) no correlation between adrenaline content in the various tissues was discovered. With the consecutive effects of cooling and immobilization, positive correlations were found between the adrenaline content in the blood and adrenal glands, in the blood and hypothalamus, in the blood and heart, and in the adrenal glands and heart. The histochemical studies substantiated the above data.

SOURCE: Fiziologicheskii Zhurnal 60(4): 540-547, 1974

AUTHOR(S): Max, S.R., R.E. Mayer, and L.Vogelsang

EXPERIMENT TITLE: Lysosomes and Disuse Atrophy of Skeletal Muscle

SUBJECTS: Male Wistar rats (175-250 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Disuse atrophy of gastrocnemius muscle was produced by skeletal fixation. A 25-gauge needle was driven through the calcaneus into the shaft of the distal tibia, and a 21-gauge needle was driven through the distal femur into the proximal tibia. The contralateral gastrocnemius served as the control. After 1-15 days following skeletal fixation, rats were anesthetized, and the gastrocnemius muscles were removed, dissected free of fat and connective tissue, weighed, and homogenized. The specific activities of the acid hydrolases, β -glucosidase, β -galactosidase, β -N-acetylhexosaminidase, arylsulfatase, and acid phosphatase were measured during the time course of disuse atrophy.

IMMOBILIZATION METHOD: Internal fixation with needles

RESULTS: The specific activity of β -glucosidase increased to 180% of the control level by the 2nd day following the production of disuse, and to 400% of the control level by the 12th day. The specific activities of β -galactosidase, β -N-acetylhexosaminidase, arylsulfatase, and acid phosphatase were increased markedly by the 12th day. All enzyme activities returned to control levels by the 15th day. The early increase in the activity of β -glucosidase indicates that lysosomal enzymes may play an important role in the etiology of disuse atrophy.

SOURCE: Archives of Biochemistry and Biophysics 146: 227-232, 1971

AUTHOR(S): Mayer, R.F., R.E. Burke, and K. Kanda

EXPERIMENT TITLE: Immobilization and Muscle Atrophy

SUBJECTS: 4 Cats

AREA OF STUDY: Muscular

OBJECTIVES: To determine the effect of chronic joint immobilization on the physiological, histochemical, and morphological characteristics of individual motor units in the cat medial gastrocnemius

PROTOCOL: Immobilization of ankle extensors and flexors at about 90° was achieved in one hindlimb of the cats by inserting steel pins spanning the knee and ankle joints. The leg was held in the flexed posture throughout the experiment. After 6-7 mo survival period, the properties of immobilized and contralateral medial gastrocnemius (MG) muscles were compared and the motor unit population of immobilized MG was surveyed with the animal under pentobarbital anesthesia. Measurements: EMG.

IMMOBILIZATION METHOD: Steel pins

RESULTS: Immobilization induced shorter MG muscle twitch contraction and semirelaxation times. Mean MG wet weight was 59% of that on the contralateral side. Most of the 78 motor units studied in the immobilized MG muscles could be classified into type groups by the same criteria used for normal MG motor units with 2 exceptions: both had fast twitch contraction times but no identifiable "sag" property and both showed little fatigue resistance and very small tetanic output. The largest difference in mechanical properties was that the mean twitch and tetanus tensions in immobilized units were smaller than in normal cats. FF-type fibers comprised 55-63.5% of restrained muscles vs 51-56% in contralateral muscles.

SOURCE: Transactions of the American Neurological Association 101: 145-150, 1976

AUTHOR(S): Mayer, R.F.

EXPERIMENT TITLE: Structure and Function of the Motor Unit: Effects of Immobilization, Monoparesis or Paraplegia

SUBJECTS: 14 Adult cats, adult rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Five groups: 1) 10 cats, immobilization of ankle extensors and flexors at about 90° in 1 hind limb by inserting steel pins spanning the knee and ankle joints. The cats were observed for periods of 3-5 wk, 4 and 6 mo. The contralateral limb served as the control; 2) 2 cats with acute (2-3 wk) unilateral antero-lateral section of the spinal cord; 3) 2 cats with chronic (6-7 mo) unilateral antero-lateral section of the spinal cord; 4) adult control rats; 5) adult rats with paraplegia and hypertonic hind limbs induced by a single intrathecal injection (lumbar 2-4) of 6-amino-nicotinamide. In vivo studies of whole muscle contractile properties were carried out on the extensor digitorum longus and soleus muscles in the rats from 14 to 570 days after the injection. The rats were then killed, and these muscles were removed. The gastrocnemius and soleus muscles were removed from the cats. All muscles were processed into thin cross-sectional slides stained with histochemical reactions. The cats were monitored, while living, with periodic EMG recording of tetanic tensions and twitch-tetanus ratios.

IMMOBILIZATION METHOD: Pinning; Cordotomy; Chemically induced paraplegia

RESULTS: Immobilized cat limbs: atrophy after 5 wk. Twitch and tetanic tensions decreased after 5 wk, and continued to do so. The mean cross-sectional area of histochemically typed fibers was decreased by 5 wk, but was decreased prominently by 6 mo. Antero-lateral cord section in cats: no atrophy, and no decrease in twitch or tetanic tensions. Hypertonic paraplegia in rats: twitch and tetanus tensions decreased, and twitch-tetanus ratios increased. The mean area of all fiber types decreased as early as 14 days. Type IIA and IIC fiber areas decreased more than type I.

SOURCE: Electroencephalography and Clinical Neurophysiology (Suppl.34): 479-485, 1978

AUTHOR(S): McEwen, G.N., Jr.

EXPERIMENT TITLE: Thermoregulatory Responses of Restrained Versus Unrestrained Rabbits

SUBJECTS: 3 New Zealand white rabbits

AREA OF STUDY: Circulatory; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Data based on a minimum of 25 experiments at ambient temperatures of 0, 10 and 20°C. Each experiment consisted of an acclimation period in the test chamber to permit metabolism to reach its resting level followed by a 30-min period of data collection. Each animal was exposed to only one ambient temperature and one experimental period while either restrained or unrestrained on any given day. The restraining device consisted of a Plexiglas collar. Measurements: metabolism, breathing rate, heart rate, rectal temperature, ear temperature.

IMMOBILIZATION METHOD: Plexiglas collar

RESULTS: Metabolism and heart rate were significantly higher with restraint at all ambient temperatures. Restraint caused an increase in energy expenditure of approximately 32%. Rectal temperatures did not change significantly during any of the experiments and heat losses due to vasometer state and respiratory evaporative water loss were not significantly different between the two experimental states. The postural change caused by the restraint was therefore implicated as the primary cause of the increased heat production.

SOURCE: Life Sciences 17(6): 901-905, 1975

AUTHOR(S): Mclean, J.H. and W.P. Coleman

EXPERIMENT TITLE: Temperature Variation During the Estrous Cycle:
Active vs Restricted Rats

SUBJECTS: 8 Female Long-Evans hooded rats (220-281 gm)

AREA OF STUDY: Metabolism and Energy Exchange; Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 4 control rats; 2) 4 experimental rats were restricted individually in hardware-cloth cylinders. All rats occupied the same room with a reversed 12-hr day-night cycle. Diet: food and water ad libitum. Measurements: colonic temperature; vaginal smear.

IMMOBILIZATION METHOD: Hardware-cloth cylinder

RESULTS: Temperatures for the control and restricted groups were about the same for all phases of the estrous cycle except early estrus. During early estrus, the restricted group showed a much greater dip in temperature than the control group.

SOURCE: Psychonomic Science 22(3): 179-180, 1971

AUTHOR(S): Medkova, I. L. and K.V. Smirnov

EXPERIMENT TITLE: Exocrinous Function of the Liver of Rats Under the Combined Influence of Transverse Accelerations and Restricted Motor Activity

SUBJECTS: Rats

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Animals were subjected to accelerations of 5 G for 20 min and then motor activity was restricted for 15 days by placing the animals in special small-volume Plexiglas cages. After restrictions the animals were again exposed to the same accelerations. Cannulation of the general bile duct was performed to investigate the principal components of bile secretions in the liver. Bile formation was studied 3 hr, 1, 3, 6, 12, 20, 35, 50, 70, 80 and 90 days after ending exposure.

IMMOBILIZATION METHOD: Cage (small plexiglas)

RESULTS: Exposure to acceleration and immobilization caused considerable changes in the excretion of cholic acid, the lipid complex and total phosphorus. In the course of the prolonged aftereffect period, there was an intensification of liver production of these substances. A normalization of these indices occurred by the 50th day.

SOURCE: Space Biology and Medicine 9(2): 131-133, 1975

AUTHOR(S): Meeroff, J.C., G. Paulsen, and P.H. Guth

EXPERIMENT TITLE: The Role of Bile Reflux in the Development of Cold-Restraint Gastric Lesions

SUBJECTS: 40 Male Sprague-Dawley rats (130-185 gm)

AREA OF STUDY: Digestive; Blood

OBJECTIVES: In title

PROTOCOL: Animals were fasted but had free access to water for 24 hr prior to study. 4 groups: 1) sham operation and no stress; 2) sham operation and cold-restraint stress; 3) pyloric ligation and cold-restraint stress; 4) bile duct ligation and cold-restraint stress. All animals were operated on under ether anesthesia. After recovery from anesthesia, the animals were restrained in a Bollman cage. Stiff plastic rods were inserted into the cage to restrict lateral, upward, and leg movements. The cage was secured with adhesive tape. After 10 min in the cage, the animals were placed in a cold room (4-6°C) for 3 hr. Group 1 animals remained unrestrained at room temperature for the 3-hr period. After 3 hr of cold-restraint stress, the animals were reanesthetized with ether, the stomachs removed, blood taken from the heart, and the animals sacrificed. Measurements: severity of lesions; hematocrit.

IMMOBILIZATION METHOD: Cage and plastic rods

RESULTS: The mean lesion scores of all cold-restraint groups were similar and much higher than in the controls ($p < .001$) and hematocrit readings were lower than in controls ($p < .05$). There was a correlation between mucosal lesion severity and hematocrit readings ($p < .001$). Bile reflux was not necessary for formation of cold-restraint stress lesions.

SOURCE: Digestive Diseases and Sciences 20: 365-369, 1975

AUTHOR(S): Meerson, F.Z., V.I. Kapelko, M.S. Gorina, A.N. Shchegolkov,
and N.P. Larionov

EXPERIMENT TITLE: The Effect of Hypokinesia on the Contractile Function
and Nervous Regulation of the Heart

SUBJECTS: Young rabbits

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinetic in individual tight cages for 3 mo. Acute experiments were performed on all the rabbits under urethane anesthesia with an open chest and artificial respiration. Measurements: pumping function of the heart; contraction and relaxation processes of the cardiac muscle; body weight; weight of left ventricle.

IMMOBILIZATION METHOD: Cage (individual tight)

RESULTS: The contraction and relaxation rate of the cardiac muscle decreased with an unchanged contraction force during hypokinesia. There was a greater depression of the cardiac contractile function with an increase in the contraction rate, a reduced adrenoreactivity, but an increased cholinoreactivity. The rabbits' weight increased slowly, or even decreased during hypokinesia. The weight of the left ventricle in these animals, despite the weight loss, was 34% greater, while the relative weight was 63% greater.

SOURCE: Fiziologicheskii Zhurnal SSSR Imeni I M Sechenova 64: 1138-1144,
1978

AUTHOR(S): Meininger, G.A., D.R. Deavers, and X.J. Musacchia

EXPERIMENT TITLE: Electrolyte and Metabolic Imbalances Induced by Hypokinesia in the Rat

SUBJECTS: Male Sprague-Dawley rats

AREA OF STUDY: Fluid and Electrolyte; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) hypokinesia - 7 days, rats were suspended in a harness with a 4° head down tilt, forelimbs could be used normally but hindlimbs were not weight bearing; 2) controls. Diet: normal. Measurements: body weight; Na, K, H₂O, Ca and urea levels; protein/day.

IMMOBILIZATION METHOD: Harness

RESULTS: During the 1st 3 days, a negative H₂O, Na, and K balances, and a weight loss were observed. Days 4-7: positive balance of H₂O, Na, and K; slow weight gain. Calcium balance was positive for the 7 day period. Urea loss by the hypokinetic rats was significantly elevated over the control rats. There was an increase in serum urea and renal papillary urea. Hypokinetic rats consumed less protein per day than did controls.

SOURCE: Federation Proceedings 37(3): 663, 1978.

AUTHOR(S): Meitner, E.R. and E. Proksova

EXPERIMENT TITLE: Micromorphology of Neurosecretion in Neurohypophysis of Rats Under Experimental Conditions

SUBJECTS: Female Wistar rats (5 mo old)

AREA OF STUDY: Endocrine; Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: Groups: 1) 21 days in complete darkness with ad libitum water intake; 2) constantly exposed to 6 100W fluorescent lamps for 21 days with 20 ml water intake per day; 3a) 23-hr immobilization for 9 days with ip water intake (20 ml/day); 3b) 23-hr immobilization for 8 days with total water withdrawal; 3c) 23 hr immobilization for 6 days with access water (40 ml/day). Measurement: quantity of neurosecretion.

IMMOBILIZATION METHOD: Mechanically immobilized

RESULTS: The quantity of neurosecretion after a long stay in the dark was found to exceed the norm. In animals subjected to immobilization stress the picture of neurohypophysis remained unchanged; it changed only in correlation with the administered water. Immobilization stress had no substantial influence upon the quantity of neurosecretion in the neurohypophysis.

SOURCE: Biologia 25(12): 857-860, 1970

AUTHOR(S): Meitner, E.R.

EXPERIMENT TITLE: Effects of Immobilization on Spermiogenesis

SUBJECTS: 12 Adult Wistar rats

AREA OF STUDY: Reproductive

OBJECTIVES: In title

PROTOCOL: Four groups: 1) controls; 2) immobilized for 24 hr; 3) immobilized for 48 hr; 4) immobilized for 96 hr. The testes were removed immediately following decapitation, and subjected to HE staining and to enzymatic reactions. Measurements: sperm cell population changes; activity of acid phosphatase, alkaline phosphatase, non-specific esterases, and glucose-6-phosphate.

IMMOBILIZATION METHOD: Not stated

RESULTS: Immobilization had varying effects on the activity of the studied enzymes. With the exception of acid phosphatase and the glucose-6-phosphatase which showed activity after 24 and 48 hr, activity in the case of acid and alkaline phosphatase and of non-specific esterases was negative. It was noteworthy that following a 96-hr immobilization the activity of acid phosphatase exceeded that of the control animals and that other enzymes, with the exception of glucose-6-phosphatase, showed signs of activity. Even taking into account the individual immobilization groups (24, 48 and 96 hr), the behavior of enzyme activity varied. After initial negativity it again became positive. Cell population changes of seminiferous tubules were most pronounced following the 96-hr immobilization. There were two morphological states. In part there occurred a complete restoration of the spermiogenic layers of the tubules with a practically empty lumen, in part there occurred the formation of numerous irregularly distributed large cell elements with pathological mitoses.

SOURCE: Acta Anatomica 95: 300-308, 1976

AUTHOR(S): Melichna, J. and E. Gutmann

EXPERIMENT TITLE: Stimulation and Immobilization Effects on Contractile and Histochemical Properties of Denervated Muscle

SUBJECTS: Wistar rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Experiment 1 - Stimulation: the sciatic nerves were cut on both sides. A thin disc of platinum with the electrodes was fixed by thin ligatures to the fascia covering the tibialis anterior muscle and the uninjured muscle was stimulated continuously. Tetanic stimulation of 300 msec duration at a frequency of 60 Hz, the rate of stimulation was 4/min and was followed by a 2-min rest period. Stimulation of the muscle was started either immediately or 7 days after denervation and continued for 3 days. Experiment 2 - Immobilization: rats were immobilized at the ankle and knee joint with a plaster cast in the extended or flexed position. The sciatic nerve was interrupted on both sides. Extensor digitorum longus and soleus muscles were removed 7 or 14 days after immobilization. Measurements: contractile properties (contraction time, latency period, maximal rate of tension development, half relaxation time, and isometric twitch tension); myofibrillar ATPase activity; succinic dehydrogenase activity; muscle weight.

IMMOBILIZATION METHOD: Plaster cast: Denervation

RESULTS: Chronic stimulation resulted in a decrease of wet weight loss and shortening of contraction time, maximal rate of isometric tension development and relaxation time. This effect was observed only when stimulation was started immediately after denervation. Hind limb immobilization resulted in prolongation of contraction time of the denervated extensor digitorum longus muscle when performed in the extended limb position, but shortening of contraction time when performed in the flexed position. Immobilization in extension resulted histochemically in a decrease of myosin ATPase activity and an increase of oxidative SDH enzyme activity. Atrophy of EDL muscle fibers was more marked after immobilization in the flexed position. Hind limb immobilization did not result in significant changes in contractile properties in the soleus muscle.

SOURCE: Pfluegers Archiv 352: 165-178, 1974

AUTHOR(S): Melik-Aslanova, L.L. and I.D. Frenkel

EXPERIMENT TITLE: Effect of Sinusoidal Modulated Currents and Acute Hypoxia on Corticosterone Content and Activity of Certain Dehydrogenases in Tissues of Different Rat Organs During Hypokinesia

SUBJECTS: 115 Male rats (140-160 gm)

AREA OF STUDY: Endocrine; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two series of experiments: 1) 62 rats - 3 groups: a) 18 controls; b) 19 hypokinetic in box cages for 30 days; c) 25 hypokinetic plus exposed to sinusoidal modulated currents (SMC); 2) 53 rats - 3 groups: a) 17 controls; b) 22 hypokinetic; c) 14 hypokinetic plus exposed to SMC. All rats in Series 2 were exposed to the effect of acute hypoxia after the 30 day experiment at a simulated altitude of 11,000 m for 3-4 min. Measurements: body weight; rectal temperature; corticosterone content in the adrenal glands, blood plasma, liver, heart and skeletal muscle; activity of the pyruvate-dehydrogenase (PDG), α -ketoglutarate-dehydrogenase (α -KDG), succinate-dehydrogenase (SDG) and malate-dehydrogenase (MDG) in the liver and brain.

IMMOBILIZATION METHOD: Cage (box)

RESULTS: The effects of SMC during 30 day hypokinesia increased the reduced glucocorticoid activity in the organism and intensified the process of oxidizing metabolism in the liver and brain. The resistance of the hypokinetic animals to acute hypoxia was normalized, which was governed by certain peculiarities in the changes of the glucocorticoid function of the adrenal cortex and the activity of a number of dehydrogenases in the Krebs cycle.

SOURCE: Voprosy Kurortologii, Fizioterapii i Lechebnoi Fizicheskoi Kultury No.1: 59-65, January/February 1978.

AUTHOR(S): Melkonyan, M.M., E.A. Araragyan, E.M. Mikayelyan, and V.G. Mkhitaryan

EXPERIMENT TITLE: Lipid Peroxidation Intensity and Vitamin E Level in Tissues after Immobilization Stress

SUBJECTS: Albino male rats (150-200 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Animals were immobilized by fixing the head and extremities daily for 150 min. Vitamin E and lipid peroxide content in the tissues (heart, liver, blood, brain) was studied immediately and 24 hr and 48 hr after one-, two- and five-time immobilization.

IMMOBILIZATION METHOD: Not stated

RESULTS: In the post-stress period after immobilization, lipid peroxides and Vitamin E levels in tissues increased considerably. The greatest residual shifts in the intensity of the lipid peroxidation occurred after the initial effect of the stress factor. After 5 immobilizations, the level of lipid peroxides exceeded that of the controls by 235-250% in the brain and heart respectively even after 48 hr. The Vitamin E content of the blood, heart, liver and brain was insignificantly altered in phase during the post-stress period. Vitamin E levels dropped below that of the controls by 10-20% within 24 hr after two immobilizations (blood and heart); and 24 hr and 48 hr after 1 and 5 immobilizations (heart and liver).

SOURCE: Zhurnal Eksperimentalnoi i Klinicheskoi Meditsiny 18(4): 25-30, 1978

AUTHOR(S): Melkonyan, M.M., E.A. Araratyan, E.M. Mikayelyan, and
V.G. Mkhitaryan

EXPERIMENT TITLE: Intensity of Lipid Peroxidation and Level of Vitamin
E After Immobilization Stress

SUBJECTS: Male white rats (150-200 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) immobilization by restraint
of the head and extremities for 150 min daily for either 1, 2 or 5
days. Vitamin E content and lipid peroxides in the brain, heart, liver
and blood were studied immediately after and 24 and 48 hr following
immobilization.

IMMOBILIZATION METHOD: Not stated

RESULTS: Lipid peroxide and Vitamin E content in the tissues increased
considerably in the post-immobilization period. The increase was greatest
in the heart immediately following immobilization, but was greatest in
the brain 48 hr after immobilization. α -tocopherol levels rose in tissue
during immobilization stress. Vitamin E increased sharply in all tissues
during stress and immediately following the 1st stress period.

SOURCE: Zhurnal Eksperimentalnoi i Klinicheskoi Meditsiny 18(4):
25-30, 1978

AUTHOR(S): Mel'nik, B.E. and E.S. Paladiy

EXPERIMENT TITLE: The Content of Catecholamines in the Adrenal Glands and Sections of the Brain Under Hypokinesia and Injection of Some Neurotropic Agents

SUBJECTS: Rats (160-200 gm)

AREA OF STUDY: Endocrine; Pharmacology

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 7, 14 and 21 days of immobilization; 2) 7 and 14 days of immobilization with daily injections of either mellepramine (6 mg/kg) or spasmolytin (4 mg/kg); 3) controls. Measurements: catecholamines in the adrenals, hypothalamus, cerebral hemispheres, cerebellum and medulla oblongata determined fluorometrically.

IMMOBILIZATION METHOD: Cage (individually sized and shaped)

RESULTS: Profound changes in body catecholamine balance occurred as a result of prolonged immobilization. Adrenaline retention increased and noradrenaline retention decreased in the adrenals, hypothalamus, cerebral hemispheres, cerebellum and medulla oblongata. Mellepramine increased catecholamine retention in the tissues studied, while spasmolytin brought about an increase in adrenaline concentration in the adrenals and a decrease in the brain.

SOURCE: Biologicheskie Nauki 15(11): 45-49, 1972

AUTHOR(S): Meltzer, H.Y.

EXPERIMENT TITLE: Muscle Toxicity Produced by Phencyclidine and Restraint Stress

SUBJECTS: Male Sprague-Dawley rats (150-175 gm); Male guinea pigs (175-200 gm)

AREA OF STUDY: Muscular; Pharmacology

OBJECTIVES: In title

PROTOCOL: Animals were housed in groups of 6 in a temperature controlled room of $22^{\circ}\pm 1^{\circ}\text{C}$ with a 12 hr light-dark cycle. 5 stress conditions: 1) restrained in rigid plastic lucite cages at room temperature for 2 hr; 2) restrained in cheese cloth for 30 min to 2 hr; 3) exposure in individual metal cages in a cold room (2°C) after wetting with the detergent Tween-80 to promote hypothermia for 2 hr; 4) grid shocks at 22°C in individual cages with a grid floor through which passed 1.5 ma for 1 sec every 10 sec for 2 hr; 5) vibration at 22°C in groups of 2 in a large plastic cage mounted on a mechanical shaker vibrating at 180 oscillations per min. Animals in each group received saline or phencyclidine before stress. At the termination of the experiment, blood was collected and analyzed, and the vastus lateralis was studied morphologically. Measurements: plasma creatine phosphokinase (PCPK); plasma lactic dehydrogenase; plasma aldolase; isoenzymes of creatine phosphokinase (CPK); vastus lateralis fibers with necrosis or other abnormalities.

IMMOBILIZATION METHOD: Cage; Cheese cloth

RESULTS: Increased PCPK levels in rats restrained at room temperature for 30 min was enhanced by pretreatment with phencyclidine in doses from .5-10 mg/kg ip but not doses of 15-50 mg/kg. Large amounts of type III (skeletal muscle) CPK and smaller amounts of type I (brain type) CPK were present in the plasma following phencyclidine and restraint at room temperature. The PCPK levels in restrained guinea pigs or other forms of stresses in the rats were not affected by pretreatment with phencyclidine. Phencyclidine administration prior to 2 hr restraint at room temperature produced observable skeletal muscle injury.

SOURCE: Research Communications in Chemical Pathology and Pharmacology 3(2): 369-383, 1972

AUTHOR(S): Meltzer, H.Y.

EXPERIMENT TITLE: Effects of Phencyclidine and Restraint at 2°C on Rat Plasma Creatine Phosphokinase Activity

SUBJECTS: Male Sprague-Dawley rats (150-175 gm)

AREA OF STUDY: Metabolism and Energy Exchange; Pharmacology

OBJECTIVES: In title

PROTOCOL: The rats were housed in groups of 6 in a temperature controlled room of $22^{\circ} \pm 1^{\circ}\text{C}$ with 12 hr light-dark cycle. Rats were given saline or Phen (5 mg/kg) ip 15 min prior to restraint of 30, 60 or 120 min duration. In most cases restraint was achieved by placing the rats in rigid plastic lucite cages; in some studies the rats were restrained by loosely taping their limbs together, wrapping them in cheesecloth, and closing the cloth tightly with tape. Restraint temperature was either 2°C or room temperature. Measurements: rectal temperature; plasma creatine phosphokinase (PCPK) activity; creatine phosphokinase (CPK) isoenzymes.

IMMOBILIZATION METHOD: Cage (rigid plastic); Cheesecloth and tape

RESULTS: Phen plus cold restraint produced rapid and massive increases in rat PCPK activity; with Phen plus either cold restraint or restraint at room temperature of 30 to 120 min duration, the mean increases in PCPK activity were 75-125 fold. The increases in PCPK levels produced by Phen plus cold restraint began within minutes. The rate of increase in PCPK levels tapered off after 30 min of cold restraint but continued for at least 2 hr. PCPK levels continued to increase for the first 30 min after termination of Phen plus 30 min cold restraint. It declined to normal by 24 hr after termination of cold restraint. Phen itself did not alter rectal temperature. In combination with cold restraint, Phen promoted a fall in rectal temperature normally produced by this procedure. CPK isoenzymes were present in the brain, kidney, spleen, thyroid, bone marrow, platelets, liver, stomach, intestine and lung.

SOURCE: Research Communications in Chemical Pathology and Pharmacology 5(1): 117-127, 1973

AUTHOR(S): Mendlowski, B.

EXPERIMENT TITLE: Neuromuscular Lesions in Restrained Rabbits

SUBJECTS: New Zealand rabbits (24 wk old)

AREA OF STUDY: Nervous; Muscular

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls, no restraint and no dressing; 2) restraint with occlusive dressing; 3) restraint without occlusive dressing. The rabbits were restrained in stocks. The hind legs were more restrained than the front. Group 2 rabbits' back skin was shaved and wrapped with an occlusive dressing. A physiologic saline solution (0.5 ml) was applied to the skin of all animals daily. Restraint lasted for 6 hr. Measurements: peripheral nerve degeneration; spinal cord lesions; skeletal muscle necrosis; lumbar kyphosis.

IMMOBILIZATION METHOD: Stock

RESULTS: Changes resulting from restraint included degeneration of the peripheral nerves and skeletal muscle necrosis. Six restrained rabbits developed lumbar kyphosis. The lesions and clinical signs, such as degeneration of sciatic nerves, were found only in restrained animals regardless of the use of occlusive dressing.

SOURCE: Veterinary Pathology 12: 378-386, 1975

AUTHOR(S): Menendes, A., R.A. Zavalishina, and A.A. Pokrovskiy

EXPERIMENT TITLE: Study of Phosphatase Activity in Bone Tissue and Blood Serum During Ninety-Day Hypokinesia

SUBJECTS: 180 Male Wistar rats (~ 200 gm)

AREA OF STUDY: Skeletal; Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 80 control rats; 2) 100 experimental rats were placed in special small-volume plexiglas cages. The control and experimental rats were simultaneously killed by decapitation (6-10 rats) on day 15, 30, 60 and 90 of the experiment; blood was collected and the hip bones were removed. Diet: synthetic. Measurements: alkaline and acid phosphatase; protein content.

IMMOBILIZATION METHOD: Cage (plexiglas)

RESULTS: Phasic changes in phosphatase activities were found in bone tissue. During the initial period of hypokinesia, both enzymes decreased in comparison to controls, with alkaline phosphatase being greater. After stress, activities of both phosphatases increased (particularly acid phosphatase in the diaphysis) and by the end of testing were higher than the enzyme activity level in controls. Alkaline phosphatase activity in the serum varied in parallel with enzyme activity in bones.

SOURCE: Space Biology and Aerospace Medicine 10(1): 32-38, 1976

AUTHOR(S): Menguy, R.

EXPERIMENT TITLE: Effects of Restraint Stress on Gastric Secretion in the Rat

SUBJECTS: Holtzman rats (200-300 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Restraint stress was produced by placing the rats in a restraining jacket of fine wire mesh; the rats' paws which protruded through holes in the wire were immobilized with adhesive tape. The animals were then suspended individually from laboratory stands. Three series of experiments: Series 1 - Rats were not fasted prior to 20-hr restraint; they were given saline (2.5 ml/100 gm animal weight) while being placed in restraint. After restraint they were killed and their stomachs removed. Twenty controls. Series 2 - Gastric secretion was measured by pylorus ligation in 40 rats previously fasted for 48 hr; 20 were controls and 20 were restrained. Six hr later they were killed and their stomachs removed. Series 3 - Pituitary gland, adrenals, and vagus nerves were studied; 15 were hypophysectomized 2 wk prior to restraint and 15 were not; 20 were bilaterally adrenalectomized prior to restraint and 10 were sham operated; and 19 were bilaterally vagectomized and 16 had the vagi exposed prior to restraint. All animals received 5 ml of saline per 100 gm animal weight sc. Rats were submitted to restraint stress for 20 hr. Measurements: free HCl excretion; gastric secretion.

IMMOBILIZATION METHOD: Mesh wire jacket and adhesive tape

RESULTS: One to ten superficial hemorrhagic gastric erosions appeared in 100% of the stressed rats. HCl output was inhibited by 94% in stressed rats. Postrestraint there was a 100% incidence of gastric erosions in hypophysectomized rats. 13 bilaterally adrenalectomized rats survived 20 hr; the glandular portion of the stomach had large hemorrhagic ulcers. Vagotomy provided significant protection against ulceration (36% ulcerations vs. 100% in vagi-exposed rats).

SOURCE: American Journal of Digestive Diseases 5(11): 911-916, 1960

AUTHOR(S): Mercier, J., G. Assouline, and J. Fondaral

EXPERIMENT TITLE: Electrocorticographic Modifications Observed in Albino Rats Under Restraint

SUBJECTS: 21 Female Wistar rats (200 gm)

AREA OF STUDY: Nervous; Digestive

OBJECTIVES: In title

PROTOCOL: Permanent cortical electrodes were implanted in the frontal cortex. After 1 wk the animals were fasted for 24 hr and then subjected to 7 hr of restraint in a bottomless parallelepipedic box while EEGs were recorded in a bipolar montage at the frontal, parietal and occipital cortex levels. At the end of the restraint period the animals were killed and their stomachs removed. Measurements: EEG; total duration of weak frequency and high voltage (synchronized events); incidence of ulcers.

IMMOBILIZATION METHOD: Parallelepipedic box

RESULTS: The percentage of synchronized phases in the EEG patterns increased from the 2nd to the 7th hr of restraint. Animals with no gastric ulceration showed a significantly greater synchronization of the EEG patterns than the animals with ulcers.

SOURCE: Comptes Rendus des Seances de la Societe de Biologie et de ses Filiales 161(7): 1639-1641, 1967

AUTHOR(S): Meyerson, F.Z., V.I. Kapel'ko, M.S. Gorina, A.N. Shchego1'kov,
and N.P. Larionov

EXPERIMENT TITLE: Effect of Hypokinesia on Cardiac Contractile Function
and Nervous Regulation of the Heart

SUBJECTS: Rabbits

AREA OF STUDY: Cardiovascular; Nervous

OBJECTIVES: In title

PROTOCOL: Hypokinesia: 3 mo in narrow cage. Measurements: pressure in the
left ventricle and blood flow through the aorta and left carotid artery.
The above were also measured when the heart was electrically stimulated or
injected with norepinephrine; cholinoreactivity excitation of the vagus nerve
following bilateral vagotomy.

IMMOBILIZATION METHOD: Cage (narrow)

RESULTS: Hypokinesia produced cardiac deadaptation which resulted in the
diminishing of the left ventricular rate of contraction and relaxation,
joined later by decreased vascular resistance. As a result the ejection
rate, stroke volume and cardiac output were normal. The decrease of re-
laxation speed became more obvious at a high heart rate and resulted in
shortening of the diastolic pause and diminishing of cardiac output. The
hearts were characterized by normal maximal pressure, decreased adrenore-
activity, and increased cholinoreactivity.

SOURCE: Fiziologicheskii Zhurnal SSSR 8: 1138-1144, August 1978

AUTHOR(S): Mezhlumyan, A.A.

EXPERIMENT TITLE: Effect of Regeneration of the Spleen Under Different Conditions on Its Megakaryocytes in Albino Rats

SUBJECTS: 190 Male albino rats (230-250 gm)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Seven groups: 1) partial splenectomy only; 2) intact, subjected to 11 G-force by spinning them on a centrifuge; 3) partial splenectomy, subjected to 11 G-force; 4) intact, subjected to 11 G-force, then administered splenic extract; 5) partial splenectomy, subjected to 11 G-force, then administered splenic extract; 6) intact, hypokinesic; 7) partial splenectomy, hypokinesic. Hypokinesia was created by placing the rats in special containers. Rats were decapitated after 3, 5, 7, 10, 15, 20 and 30 days. [³H]thymidine was injected into all the animals 1 hr before sacrifice. The spleen was removed and processed for histological analysis. Measurements: number, distribution, size and form of megakaryocytes.

IMMOBILIZATION METHOD: Container

RESULTS: Megakaryocytes were found in the intact rats in forms ranging from small cells with a ring-shaped nucleus to large, multinuclear cells. During regeneration of the spleen, the number of megakaryocytes increased sharply. Gravitational overloading doubled the number of megakaryocytes and increased mitotic activity. Administration of splenic extract + gravitational overloading reduced the number of megakaryocytes, but increased mitotic activity. During hypokinesia, the number of megakaryocytes in the regenerating spleen fell sharply and no mitoses were observed.

SOURCE: Bulletin of Experimental Biology and Medicine 84(8): 1186-1189, 1977

AUTHOR(S): Michailov, M.L., U. Gnuechtel, St. Nitschkoff, R. Baumann,
and G. Gnauck

EXPERIMENT TITLE: The Behavior of Fatty Acids in the Blood Plasma of
Monkeys Following Exposure to Short Term Stresses

SUBJECTS: 2 Male baboons (22.7 kg); 2 female baboons (10.4 kg)

AREA OF STUDY: Circulatory; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Following a 12 hr fast 2 experiments were performed: 1) immobilization - the female baboons were fastened to a board in a supine position for 20 min in a way that made it possible for them to see monkeys moving about freely; 2) jealousy - the male baboons were isolated from their herd and saw their mates in the company of other males for 20 min. Measurements: behavior; blood pressure; blood analyzed for fatty acid content and blood glucose.

IMMOBILIZATION METHOD: Board

RESULTS: In males the systolic and diastolic blood pressure rose whereas in females there was no discernable change. The monkeys exposed to the stresses were found to develop hyperlipacidemia with a rise in concentration of unsaturated fatty acids in blood plasma (especially oleic acid) and a relative decrease of saturated free fatty acids (chiefly, palmitic acid). This finding was more pronounced under immobilization stress than in the jealousy situation. The composition of triglycerines did not essentially change under the conditions used. A hyperglycemic reaction was found during both stresses.

SOURCE: Acta Biologica et Medica Germanica 32: 675-680, 1974

AUTHOR(S): Michelsson, J.E. and A. Langenskiöld

EXPERIMENT TITLE: Coxa Vara Following Immobilization of the Knee in Extension in Young Rabbits

SUBJECTS: Rabbits (2-12 wk old)

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Restraint: 3-4 wk or up to 8 wk. One of the hind limbs was immobilized with the knee in extension, but with the hip free to move. The immobilization was accomplished either by a plastic tube fixed proximally to the skin of the femur (62 rabbits) or by a metal pin applied dorsally in the soft tissues of the limb (8 rabbits). In another 25 rabbits, the hamstring muscles were cut proximally or distally just before the immobilization of the knee in extension of the same limb was performed.

IMMOBILIZATION METHOD: Plastic tube; Metal pin

RESULTS: 63 of 70 rabbits had some hip abnormality and 7 had no permanent damages: 25 had coxa vara only, 10 had coxa vara and hip subluxation, 15 had coxa vara and hip dislocation, 9 had dislocation only, and 4 had subluxation only. Marked pathological changes of the hip, including coxa vara, occurred most frequently in those rabbits that were 3-6 wk old when the immobilization was begun. In the oldest rabbits (8-12 wk old) usually no changes or only slight ones developed in the hip of the immobilized limb. In coxa vara, both the acetabulum and the proximal end of the femur were deformed and the head and the neck of the femur were usually retroverted.

SOURCE: Acta Orthopaedica Scandinavica 45: 399-411, 1974

AUTHOR(S): Michelsson, J.E., T. Videman, and A. Langenskiöld

EXPERIMENT TITLE: Changes in Bone Formation During Immobilization and Development of Experimental Osteoarthritis: A Study Using Oxytetracycline in Rabbits

SUBJECTS: 26 Rabbits, growing (2-5 mo old) and adult (9-33 mo old)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: One right hind limb of 11 growing and 13 adult rabbits was immobilized with a plastic splint and tensoplast so that the knee was held in extension but the hip was free. The splint was removed after 2-17 1/2 wk and the animals allowed to move freely. The animals were killed 0-78 wk after immobilization. 9 of the adult and all the 11 growing rabbits were given injections of oxytetracycline (50 mg/kg) im on 3 consecutive days 1-13 days before death. The other 4 adult rabbits were given the oxytetracycline at the beginning of immobilization and were killed 49-90 days later. The hips and knees of the immobilized and non-immobilized legs were dissected free. Measurements: oxytetracycline content of legs.

IMMOBILIZATION METHOD: Plastic splint and tensoplast

RESULTS: In the knee, degenerative changes developed consistently with a severity proportional to the length of immobilization time. In most of the rabbits given oxytetracycline 1-13 days before being killed more oxytetracycline was incorporated in the immobilized knee and hip region than the control knee and hip.

SOURCE: Acta Orthopaedica Scandinavica 48: 443-449, 1977

AUTHOR(S): Midrio, M., F. Bouquet, M. Durighello, and T. Princi

EXPERIMENT TITLE: Role of Muscular Disuse in the Genesis of Fibrillation in Denervated Muscle

SUBJECTS: Adult albino rats (250-300 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Three groups: 1) the spinal cord was sectioned and one sciatic nerve was cut 1-15 days later; 2) both hind limbs were immobilized by plaster cast, 1 limb in flexion and the other in extension; after 1-15 days the cast was removed and the sciatic nerve cut on both sides; 3) the tendo calcaneus was cut on one side and 1-19 days later the sciatic nerve was cut on both sides. Electromyographic records were taken until fibrillation had fully developed.

IMMOBILIZATION METHOD: Plaster cast; Cordotomy; Tenotomy; Denervation

RESULTS: In the muscles denervated after cord section, limb immobilization or tenotomy, fibrillation appeared earlier than in controls (muscle denervated without any experimental procedure). The average lag in the onset of fibrillation gradually shortened as the interval between cord section, or limb immobilization, and denervation was prolonged, reaching a minimum of 24 hr when the interval was 5 days long. There was no difference between the effects of immobilization in flexion and in extension.

SOURCE: Experientia 29: 58-59, 1973

AUTHOR(S): Mikaleva, N.P., I.I. Ivanov, I.V. Federov, and E.M. Amdiy

EXPERIMENT TITLE: Study of the Fractional Composition of Skeletal Muscle Proteins During Hypokinesia

SUBJECTS: White male rats (160-200 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental rats subjected to hypokinesia by placing them in cages for 15, 22 and 30 days. Food was unrestricted for both groups. The rats were decapitated on termination of hypokinesia period. Measurements: body weight; water content; fractional composition of proteins of skeletal muscles; free adeny nucleotides.

IMMOBILIZATION METHOD: Cage

RESULTS: In 3 experimental series, actomyosin protein content decreased significantly, whereas T fraction and stroma protein content increased in animals subjected to hypokinesia. Differentiations in nitrogen content were insignificant. The weight of experimental animals decreased reliably by an average of 19%. Water content in the skeletal muscles remained unchanged during 15- and 22-day experiments and increased during the 30-day experiment in comparison with the controls. ATP concentration decreased significantly during the 15- and 22-day experiments but returned to the normal level by the 30th day.

SOURCE: Space Biology and Medicine 4(2): 61-68, 1970

AUTHOR(S): Mikhailenko, A.A.

EXPERIMENT TITLE: Some Morphological Manifestations of Experimental Hypodynamia

SUBJECTS: 29 Rabbits

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: The rabbits were restricted by placing them in metal cages of about the same size and shape as their body. Periods of hypodynamia were 4-8, 30, 45, 60 and 75 days. Occasionally the rabbits were allowed to mix in order to study their behavior outside the cage, and for chronaximetry and electromyography. Pieces of the brain, the brain stem at the level of the corpora quadrigemina, the cerebellum, segments of the spinal cord, the sciatic nerve, and femoral muscles were removed for histological investigation.

IMMOBILIZATION METHOD: Cage (metal)

RESULTS: Vascular disturbances were seen accompanied by change in the content of chromatophilic substance in the cells of the central nervous system, varying in character in different parts of the brain and spinal cord.

SOURCE: Bulletin of Experimental Biology and Medicine 71(6): 705-708, 1971

AUTHOR(S): Mikhaleva, N.P., I.I. Ivanov, B.F. Korovkin, and I.V. Fedorov

EXPERIMENT TITLE: Enzyme Activity and Potassium and Sodium Contents of the Skeletal Musculature and Blood Serum During Prolonged Hypokinesia

SUBJECTS: Male white rats (160-220 gm)

AREA OF STUDY: Metabolism and Energy Exchange; Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinesia in individual restraint cages for 15 to 30 days. The rats were decapitated at the end of this period. Sarcoplasmic-protein extracts of the skeletal musculature and the blood serum were used to determine the activity of the following enzymes: lactate dehydrogenase (LDH); aldolase (ALD); aspartate aminotransferase (AST); alanine aminotransferase (ALT); creatine kinase (CK); cholinesterase (CE); alkali phosphatase (ALP); and acid phosphatase (ACP). Sodium and potassium content was also determined.

IMMOBILIZATION METHOD: Cage (individual restraint)

RESULTS: Hypokinesia caused an increase in the activity of ALD, AST, ALT, and CK in the blood serum. The only time at which ALP activity was clearly elevated was on day 30. The LDH, CE, and ACP activity in the blood serum remained almost unchanged. There was a decrease in the potassium content of the blood serum and skeletal musculature during prolonged hypokinesia. The sodium concentration in the muscle tissue increased and that in the blood serum remained constant.

SOURCE: Eksperimental'nye Issledovaniya Gipokinezii, Izmenennoi Gazovoi Sredy, Uskorenii, Peregruzok i Drugikh Faktorov (ed. by V.V. Parin et al), 1968, pp. 18-21.

AUTHOR(S): Mikhaleva, N.P., G.D. Yefimenko, and I.P. Bobrovnitskiy

EXPERIMENT TITLE: Electrolyte Content of the Myocardium, Skeletal Muscles and Blood of Rats During Prolonged Hypokinesia and Readaptation

SUBJECTS: 76 Male rats (180-250 gm)

AREA OF STUDY: Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls in vivarium cages; 2) hypokinesia in small cages for 15, 30 and 49 days; 3) hypokinesia for 49 days then allowed free mobility for 5, 10 and 15 days. Upon termination of the above periods, all rats were decapitated. Diet: water and food ad libitum. Measurements: potassium and sodium content of blood plasma, erythrocytes, myocardium and femoral extensor muscles; fluid content of the myocardium and skeletal muscle.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: Potassium content of the tissues of the myocardium and skeletal muscle decreased which was more marked and occurred at an earlier time than the decrease in potassium level in plasma and erythrocytes. By the 49th day of hypokinesia, potassium levels in erythrocytes, plasma and myocardium did not differ from the controls while that of skeletal muscle remained lower (76.1%).

SOURCE: Space Biology and Aerospace Medicine 12(4): 114-116, 1978

AUTHOR(S): Mikhaylova, O.M.

EXPERIMENT TITLE: Effect of Hypokinesia on the Structure of the Neural Apparatus of Certain Rabbit Cerebral Arteries

SUBJECTS: Male rabbits (2.4-3.2 kg)

AREA OF STUDY: Nervous; Circulatory

OBJECTIVES: In title

PROTOCOL: Five groups of rabbits were severely restricted in close cages for: 1) 1 wk, 8 rabbits; 2) 2 wk, 26 rabbits; 3) 4 wk, 28 rabbits; 4) 2 mo, 22 rabbits; 5) 3 mo, 5 rabbits. At the end of each period of hypokinesia the animals were killed by means of an air embolism. Measurements: general condition; activity; physical development; behavior; state of neural apparatus and vessels of the meninx vacuolosa; survival rate.

IMMOBILIZATION METHOD: Cage (close)

RESULTS: Functional disorders appeared after 1 wk and were marked after 4 wk. After 1 mo, a period of relative stabilization set in due to the development of compensatory mechanisms. Severe disorders of the neural apparatus and the arterial lumen, including destructive changes, appeared in animals surviving 2 and 3 mo of acute hypokinesia.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii No.12: 59-64, 1974

AUTHOR(S): Mikisková, H.

EXPERIMENT TITLE: The Effect of Restraining on the Heart Rate in Guinea Pigs

SUBJECTS: Male guinea pigs, 3-4 mo or 12-18 mo old

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Three groups, each containing young and older guinea pigs: 1) restrained by being tied to a table for 6 hr, ECG taken from skin of legs; 2) moving freely in a cage, ECG by radio telemetric electrodes; 3) animals moving freely, ECG by electrodes connected to cable. The ECGs were taken for 6 1 min periods, each 1 hr apart. Measurements: heart frequency.

IMMOBILIZATION METHOD: Tied to a table

RESULTS: In immobilized animals, the heart frequency over 6 hr decreased 1.9% for the young animals, and 18% for the older animals. In freely moving animals, the heart frequency decreased gradually, especially when the cable connection was used. The changes in the younger group was 29.2% by the end of the 6th hour, 21.2% for the older group.

SOURCE: Activitas Nervosa Superior 10(4): 382-388, 1968

AUTHOR(S): Mirol'yubov, G.P., V.A. Korzhen'yants, G.P. Stupakov, A.I. Volozhin, and V.V. Korolev

EXPERIMENT TITLE: Effect of Hypokinesia on the Strength of Bone

SUBJECTS: 100 Noninbred albino rats (140-160 gm)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats were placed in small wire cages for 20, 40, 60 and 100 days. The femoral bones were taken for investigation. Measurements: external diameter of the diaphysis; width of the medullary canal, thickness of the cortical layer; static bending of bone at 35 mm/min rate of loading; mineral content.

IMMOBILIZATION METHOD: Cage (small wire)

RESULTS: The thickness of the cortex of the femur in the rats decreased markedly but the ability of the whole bone to withstand mechanical loading was only slightly reduced. An increase in mineral saturation of the bone tissue was found.

SOURCE: Bulletin of Experimental Biology and Medicine 80(10): 1171-1173, 1975

AUTHOR(S): Mkhitarian, V.G., E.A. Araratyan, E.M. Mikayelyan, and M.M. Melkonyan

EXPERIMENT TITLE: Certain Aspects of the Process of Lipid Peroxidation During Immobilization Stress

SUBJECTS: Male albino rats (150-200 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) the experimental rats were immobilized by fixing the head and extremities daily for 150 min for 1-7 days. Measurements: the content of lipid peroxides was determined in the homogenates of the heart and brain according to the levels of malonic dialdehyde (MDA); the activity of the enzyme superoxide dismutase (SOD) was measured in the same tissues.

IMMOBILIZATION METHOD: "Fixing the head and extremities"

RESULTS: In the control animals, the initial level of lipid peroxides in the heart was lower than in the brain. The activity of SOD was 2.5 times greater in the heart than in the brain. The level of lipid peroxides in the heart and brain was considerably increased as compared to the control in all periods of immobilization; the SOD in both organs was inhibited during all periods of immobilization except the 3rd and 5th.

SOURCE: Zhurnal Eksperimentalnoi i Klinicheskoi Meditsiny 17(5): 13-18, 1977

AUTHOR(S): Mollmann, H. and H.J. Egbers

EXPERIMENT TITLE: A Comparative Investigation of the Effects of Specific Psychotropic Agents on Immobilization-Induced Ulcer

SUBJECTS: 970 Female Wistar rats

AREA OF STUDY: Pharmacology; Digestive

OBJECTIVES: In title

PROTOCOL: Four groups: 1) a preliminary group of 110 rats tested for the ulcerogenic effect of Fluphenazine (F), Pentobarbital (P), Chlordiazepoxide (C) and Amitryptiline (A); 2) 140 controls; 3) rats were deprived of food and water for 24 hr and then immobilized in wire mesh wrapped around the animal with the paws protruding and bound together in pairs with elastoplast. They were suspended in a large cage in a darkened room at 20°C for 24 hr. Over a period of 2-10 days F and P, or a mixture of F and P were administered orally at varying dose levels; 4) fasted and immobilized as group 3, administered a formulation of C and A in varying doses. The rats were sacrificed by chloroform narcosis after immobilization, and their stomachs dissected. Measurements: number, size, and extent of gastric lesions.

IMMOBILIZATION METHOD: Wire mesh and cage

RESULTS: Fluphenazine in a dose of .012 mg/day, and no other size dose, caused a steady decrease in the degree of ulceration. Pentobarbital in a dose of 1.2 mg/day or 2.4 mg/day caused reduction in the degree of ulceration regardless of the period of application. The combination of F .012 mg/day with P 1.2 mg/day for 10 days caused ulceration that was 50-75% lower than that when either of the two agents were used separately. The combined preparation of Chlordiazepoxide and Amitryptiline needed a much greater dosage (.32 and 0.8 mg/day respectively) to decrease the degree of ulcer affection by 50%.

SOURCE: Internationale Zeitschrift fuer Klinische Pharmakologie, Therapie und Toxikologie 4(3): 361-372, 1971

AUTHOR(S): Moore, K.E. and E.W. Lariviere

EXPERIMENT TITLE: Effects of D-Amphetamine and Restraint on the Content of Norepinephrine and Dopamine in Rat Brain

SUBJECTS: Female Sprague-Dawley rats (180-220 gm)

AREA OF STUDY: Nervous; Pharmacology

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls, received saline or D-amphetamine injections; 2) experimental animals, received either saline or 3, 10 or 30 mg/kg D-amphetamine ip and were restrained in adjustable wire mesh cages for 4 hr. The animals were decapitated 4 hr after the injection. Measurements: brain homogenates were assayed for dopamine and norepinephrine.

IMMOBILIZATION METHOD: Cage (adjustable wire mesh)

RESULTS: The norepinephrine and dopamine concentrations in the brains of restrained animals were not significantly different from those of unrestrained animals. Norepinephrine was reduced to its lowest level in 2-4 hr and returned to control values by 72 hr. The dopamine content was only slightly reduced within the first few hours but within 4 hr had returned to control levels. Restraint did not enhance the lethality or norepinephrine-depleting action of D-amphetamine in rats.

SOURCE: Biochemical Pharmacology 12: 1283-1288, 1963

AUTHOR(S): Morgan, W.W., P.K. Rudeen, and K.A. Pfeil

EXPERIMENT TITLE: Effect of Immobilization Stress on Serotonin Content and Turnover in Regions of the Rat Brain

SUBJECTS: Male adult Sprague-Dawley rats (150 gm)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Rats were housed for 1 wk at near constant temperature ($22\pm 1^{\circ}\text{C}$) and were exposed to a 14:10 light-dark cycle. Rats were immobilized by putting their legs through holes in wire grid and adhesive taping front and back pairs of legs together. Two studies performed: 1) experimental rats immobilized for periods of 0, 30, 60, 120, 180 or 300 min and then sacrificed by decapitation; 2) experimental animals immobilized for 1 hr, administered probenecid, then sacrificed 0, 30, 60 and 90 min after the administration. Immediately after sacrifice, the brains were removed and rapidly dissected. Discrete brain areas studied: brainstem, diencephalon, hippocampus, striatum, and cerebral cortex. Measurements: serotonin (5-HT); 5-HT turnover; 5-hydroxy-indoleacetic acid (5-HIAA).

IMMOBILIZATION METHOD: Wire grid and adhesive tape

RESULTS: 5-HIAA content and 5-HT turnover rate were significantly increased in the cerebral cortex after the onset of immobilization. Immobilization increased 5-HIAA content in the brainstem but not the 5-HT turnover rate. Short-term increases in 5-HIAA content were seen in the striatum and hippocampus, but no significant 5-HT turnover changes were seen in these 2 areas. Immobilization did not affect 5-HIAA content or 5-HT turnover in the diencephalon.

SOURCE: Life Sciences 17: 143-150, 1975

AUTHOR(S): Mueller, G.P., C.P. Twohy, H.T. Chen, J.P. Advis, and J. Meites

EXPERIMENT TITLE: Effects of L-Tryptophan and Restraint Stress on Hypothalamic and Brain Serotonin Turnover, and Pituitary TSH and Prolactin Release in Rats

SUBJECTS: Male Sprague-Dawley rats (220-250 gm)

AREA OF STUDY: Nervous; Endocrine

OBJECTIVES: In title

PROTOCOL: Four experiments: 1) rats were injected with L-tryptophan (200 mg/kg) and killed 30, 60 and 120 min thereafter; 2) rats were injected with pargyline (75 mg/kg), increasing doses of L-tryptophan in combination with pargyline, or 5-hydroxytryptophan ethyl ester hydrochloride (5-HTP) and killed 30 min later; 3) rats were restrained for 0, 5, 15, 45 or 150 min before killing. Restraint was created by taping the animals to wire test tube racks and then placing them on their backs; 4) rats were injected with pargyline (75 mg/kg) 15 min prior to killing, restraint was administered for the last 5 or for the entire 15 min period. All animals were killed by decapitation; trunk blood collected and the brains removed. Diet: Purina Lab Chow and water ad libitum for 5 days prior to each experiment. Measurements: tryptophan; serotonin; 5-hydroxyindoleacetic acid (5-HIAA); thyroid stimulating hormone (TSH); prolactin (PRL).

IMMOBILIZATION METHOD: Wire test tube rack and tape

RESULTS: Serotonin turnover in the hypothalamus and remaining brain tissue minus the cerebellum was increased as determined by enhanced accumulation of serotonin following monoamine oxidase inhibition. L-tryptophan, but not restraint stress, elevated levels of tryptophan in the cerebellum. Both L-tryptophan and restraint stress inhibited TSH release and stimulated PRL release.

SOURCE: Life Sciences 18(7): 715-724, 1976

AUTHOR(S): Murdoch, J.L., R.L. Hoenes, D.A. Ekkens, C.A. Russell, and U.D. Register

EXPERIMENT TITLE: Role of the Pituitary and Adrenals in Cold and Restraint Induced Liver Nonprotein Sulfhydryl Depletion

SUBJECTS: Female Sprague-Dawley rats

AREA OF STUDY: Endocrine; Digestive

OBJECTIVES: In title

PROTOCOL: Two experiments: Experiment 1 - 5 groups: 1) controls; 2) stressed; 3) restraint adapted and stressed; 4) restraint adapted and not stressed; 5) injected with epinephrine. Each group in Experiment 1 was subdivided into intact, hypophysectomized, and hypophysectomized and given ACTH. Experiment 2 - 4 groups: 1) intact; 2) adrenalectomized; 3) adrenalectomized and given cortisol; 4) adrenalectomized and given epinephrine. Each group in Experiment 2 was subdivided into stressed or unstressed. Adrenalectomy was done one wk prior to stressing. Rats were stressed by placing them in loose-fitting cages in a refrigerated room (0-5°C) so that rectal temperatures were decreased 20°C over a 4-hr period in 2-3° increments. Those rats to be adapted to restraint were kept in cages for 5 days at room temperature. After stress the animals were decapitated and livers removed. Measurements: liver nonprotein sulfhydryl levels.

IMMOBILIZATION METHOD: Cage

RESULTS: There was a significant decrease in liver nonprotein sulfhydryl levels in intact, hypophysectomized, and adrenalectomized rats in response to cold, restraint, and epinephrine injection. Neither ACTH nor cortisol replacement was necessary for this response.

SOURCE: Proceedings of the Society for Experimental Biology and Medicine 124: 274-277, 1967

AUTHOR(S): Nachmias, V.T. and H.A. Padykula

EXPERIMENT TITLE: A Histochemical Study of Normal and Denervated Red and White Muscles of the Rat

SUBJECTS: Male Wistar rats (150-200 gm); cats and frogs

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Rats were used for most of the observations of normal muscle; a few observations were made on cats and frogs. In the experiments involving denervation, the soleus or the anterior head of the biceps femoris was denervated in one hind limb of each experimental rat; the opposite hind limb served as a control. Some control operations were performed in which the muscle was exposed and the nerve lifted, but not cut. Animals were sacrificed on the 14th post-operative day for all tests except lipides; muscles were removed immediately after killing. Lipide changes were studied at 18 to 19 days. Measurements: succinic dehydrogenase; adenosinetriphosphatase (ATPase); esterase; glycogen; lipides.

IMMOBILIZATION METHOD: Denervation

RESULTS: In normal muscle, the following observations were made: succinic dehydrogenase - the muscle fibers of the rat's soleus were uniformly and highly active. In contrast, the mixed muscles contained fibers which differed greatly in enzymatic activity. ATPase - the fibers of the soleus of the rat varied in enzymatic activity but within a given fiber there was uniform staining. Lipides - fibers of the soleus appeared alike in cross-section. Non-Specific Esterase - the soleus was found to consist of fibers of essentially equal enzymatic activity. Glycogen - in the soleus fibers were essentially uniform. In denervated muscle the following results were obtained: succinic dehydrogenase - the soleus showed a marked decrease in activity 14 days after denervation while in the biceps, there was a clear cut reduction of enzyme activity in smaller fibers but a less marked change in the larger ones. ATPase - 2 weeks after denervation there appeared to be a slight increase in the test for this enzyme in the soleus and biceps. Lipides - the denervated soleus and biceps showed a decrease in overall sudanophilia. Glycogen - there was a marked decrease in the denervated biceps and soleus.

SOURCE: Journal of Biophysical and Biochemical Cytology 4(1): 47-54, 1958

AUTHOR(S): Nasledova, I.D., P.A. Sol'nitskii, and E.A. Loskutova

EXPERIMENT TITLE: Effect of Ovariectomy and Periodic Immobilization on Some Indices of Lipid and Carbohydrate Metabolism and of Thyroid Function in Female Rabbits

SUBJECTS: Female rabbits

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Four groups: 1) 5 controls; 2) 6 rabbits, intact and immobilized; 3) 8 rabbits, ovariectomized; 4) 5 rabbits, ovariectomized and immobilized. Immobilization was carried out in cages for periods of 5 days separated by intervals of 7 days. At the end of the experiment all the animals received 0.5 μCi I^{131} . Measurements: uptake of 0.5 μCi I^{131} by thyroid; blood sugar; glucose tolerance; serum concentration of cholesterol, phospholipids, and free fatty acids (FFA).

IMMOBILIZATION METHOD: Cage

RESULTS: The immobilization reduced the glucose tolerance and led to the development of hypercholesteremia. Ovariectomy led to an increase of blood FFA and a temporary decrease in the glucose tolerance. In all experimental animals at the end of the experiment the serum cholesterol was raised and glucose tolerance lowered. In the ovariectomized animals a decrease in the uptake of I^{131} by the thyroid was observed, and this tendency was strengthened by a combination of ovariectomy and immobilization.

SOURCE: Bulletin of Experimental Biology and Medicine 78(8): 940-942, 1974

AUTHOR(S): Nelson, P.G.

EXPERIMENT TITLE: Functional Consequences of Tenotomy in Hind Limb Muscles of the Cat

SUBJECTS: Cats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls, normal muscles; 2) tenotomy, excision of 0.5 cm of the Achilles tendon; 3) denervation, removal of 0.5 cm length of the tibial nerve. Measurements were made from 3-10 wk following the operations. Measurements: electromyographic (EMG) activity; isometric twitch times; tetanus-twitch ratio.

IMMOBILIZATION METHOD: Tenotomy; Denervation

RESULTS: Section of the Achilles tendon resulted in little or no change in the EMG activity of either the soleus or gastrocnemius muscles, either in the period immediately following the tenotomy or for longer periods of several weeks. No change in the time course of the isometric twitch contraction was seen and no significant change in the tetanus: twitch ratio occurred. The tenotomy-induced atrophy of the triceps muscles was more marked in the soleus than in the gastrocnemius muscles. Contraction time of the denervated gastrocnemius muscles was prolonged while little or no change was seen in the contraction of the denervated soleus. Atrophy of the denervated gastrocnemius was more marked than that of the denervated soleus.

SOURCE: Journal of Physiology 201: 321-333, 1969

AUTHOR(S): Nemeth, S. and M. Vigas

EXPERIMENT TITLE: Adrenal Hormones and Increase of Liver Tyrosine
Aminotransferase and Tryptophan Pyrrolase Activity
After Immobilization in Rats

SUBJECTS: Adult male rats

AREA OF STUDY: Endocrine; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Some animals were bilaterally adrenalectomized one wk and others bilaterally adrenalectomized 7 wk before use. The adrenalectomized group was administered saline instead of tap water, beginning with the day of surgery. The rats were immobilized by fixing their legs with sticking tapes to a wooden desk. Controls and immobilized animals were killed at the same time. Measurements: plasma corticosterone level; liver tyrosine aminotransferase and tryptophan pyrrolase activity.

IMMOBILIZATION METHOD: Tape and desk

RESULTS: In adrenalectomized rats the postimmobilization increase of liver tyrosine aminotransferase and tryptophan pyrrolase activity was similar as in intact animals, whereas in adrenalectomized rats this response was completely absent. In intact animals a positive correlation between the magnitude of the response of both enzymes and the duration of immobilization and/or the extent of plasma corticosterone increase was observed.

SOURCE: Endocrinologia Experimentalis 9(2): 100-104, 1975

AUTHOR(S): Nemeth, S.

EXPERIMENT TITLE: Inhibitory Effect of Immobilization Stress on Depression of Liver Tyrosine Aminotransferase and Tryptophan Pyrrolase by Glucose Feeding in Rats

SUBJECTS: Adult male Wistar rats

AREA OF STUDY: Digestive; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: - A day before the experiment a 15% glucose solution ad lib replaced pelleted laboratory diet and drinking water in 50% of the subjects, for 16 hr. Two series resulted: I) rats which consumed an average amount of 34 gm glucose per kg body wt; II) rats which consumed an average amount of 53 gm glucose per kg body wt. Half of both series were subjected to forced immobilization for 2.5 hr, creating the following subgroups: 1) normal feeding; 2) 15% glucose feeding; 3) normal feeding and immobilization; 4) 15% glucose feeding and immobilization. Glucose treatment was also applied to 50% of a group of non-immobilized alloxan diabetic rats. Measurements: corticosterone; phosphoenolpyruvate carboxykinase (PEPCK); tyrosine aminotransferase (TAT); tryptophan pyrrolase (TP); plasma glucose.

IMMOBILIZATION METHOD: Metal mounts attached to a board

RESULTS: Alloxan diabetic rats: 2 of the pellet- and all of the glucose-fed rats had elevated plasma corticosterone; low glycogen level and increased activity of PEPCK, TAT, and TP were observed in most of these animals. Series I: decreased activity of both TAT and TP in non-immobilized, glucose-fed animals; glucose intake of 34 gm was insufficient for the inhibition of immobilization-induced enzyme increases. From the other parameters found after replacement of pellets by glucose, only the lower content of glycogen in non-stressed animals or in those after immobilization was found statistically significant. Increase of plasma corticosterone in stressed animals of both feeding schedules. Series II: decreased activity of both TAT and TP in glucose-fed groups, both immobilized and non-immobilized. Higher glycogen content in non-immobilized animals; increase of plasma glucose after immobilization. In Series I and II, the inhibitory effect of glucose feeding on TAT and TP was reversed after immobilization.

SOURCE: Endocrinologia Experimentalis 11(1): 43-48, 1977

AUTHOR(S): Nemeth, S., M. Vidas, R. Kvetnansky, J. Orlicky, and L. Mikulaj

EXPERIMENT TITLE: The Effect of Repeated Immobilization on the Level of Plasma Corticosterone and on the Activity of Several Liver Enzymes in Rats

SUBJECTS: Adult male rats

AREA OF STUDY: Endocrine; Digestive

OBJECTIVES: In title

PROTOCOL: Four groups: 1) immobilized for 2.5 hr daily for 6 days; 2) immobilized for 2.5 hr only once; 3) intact, immobilized for 3 days; 4) adrenalectomized, immobilized for 3 days. Animals were immobilized by inserting their heads through 2 metal loops and taping their limbs to metal mounts attached to a board. Measurements: blood plasma corticosterone and liver TAT for groups 1 and 2; for groups 3 and 4, levels of inducible enzymes glutamic-oxalacetic transaminase (GOT), glutamic-pyruvic transaminase (GPT), glucose-6-phosphatase (G6P) and fructose-1,6-diphosphatase (FDP) were measured from the liver.

IMMOBILIZATION METHOD: Metal loops, metal mounts, tape, and board

RESULTS: In group 1 and 2, plasma corticosterone increased to the same peak immediately after immobilization, but 1 hr later, decreased to below the initial values for rats conditioned to stress, whereas non-conditioned animals persisted with hypercorticosteronemia. No effect of hypercorticosteronemia was found in TAT activity. In group 3 only, GOT and GPT were increased after immobilization. In group 4, the adrenalectomized group, there was a slight increase in GOT.

SOURCE: Endokrinologie 69(1): 87-93, 1977

AUTHOR(S): Nemeth, S. and J. Hepa

EXPERIMENT TITLE: Liver Glycogen Content and Activity of Several Hepatic Enzymes in Repeatedly Immobilized Rats

SUBJECTS: Adult male Wistar rats

AREA OF STUDY: Digestive; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Five groups: 1) immobilization - 6 days, 2.5 hr daily with lowered food intake. On the 7th day, rats were killed along with animals of the following 2 groups; 2) non-immobilized, normally fed controls (CI); 3) non-immobilized, animals pair fed to the immobilized (PFI), animals of the PFI group were subjected to food restriction for 5 days only; 4) second non-immobilized pair fed groups (PFII) - killed 24 hr after the immobilized animals; 5) second non-immobilized normally fed controls (CII) - killed together with group PFII. Measurements: liver aspartate aminotransferase (AspAT); alanine aminotransferase (AlAT); liver protein and glycogen; glucose-6-phosphatase (G6P).

IMMOBILIZATION METHOD: Cage

RESULTS: There was a lower body weight of the immobilized and pair fed animals, and diminished relative liver weight of the pair fed groups. Liver protein level was increased after both immobilization and pair feeding. Glycogen content of pair fed groups was substantially decreased; the same glycogen content was found after immobilization as in controls, in spite of lowered food intake. An increase of AspAT activity of stressed animals as compared with normally fed controls and also of animals pair fed to the immobilized was found. No stimulating effect of stress was found on AlAT. Spontaneous increases of AlAT activity were observed in groups CII and PFII killed 24 hr after the remaining animals. The remaining enzymes were found uninfluenced by the stressor. Somewhat increased activity of G6P in both pair fed groups was detected.

SOURCE: Acta Physiologica Polonica 29(1): 55-60, 1978

AUTHOR(S): Nesterenko, N.T.

EXPERIMENT TITLE: Effects of Gravitational Stress, Hypokinesia and Hypodynamia on the Structure of the Vascular Bed of the Spleen

SUBJECTS: 220 Male and female albino rats

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Four groups: 1) controls; 2) stress induced by rotation on a centrifuge with a 1 m radius; 3) hypokinesia in narrow cages for periods of 1, 2, 4, 6 and 8 wk; 4) hypokinesia then stress as in group 2. The vascular bed of the spleen was studied by injecting the arterial system with a roentgenocontrast mass followed by roentgenography and microroentgenography, by injection with a Hauch mass and subsequent clearing by the Malygin method, by preparation of histological sections and subsequent Van Gieson staining and staining with hematoxylin-eosin. Extraordanic and intraorganic arteries were studied on roentgenograms and microroentgenograms, the veins in cleared preparations.

IMMOBILIZATION METHOD: Cage (narrow box)

RESULTS: Group 2: the intraorganic vessels of the 3rd and 4th order, both arterial and venous, were constricted and became tortuous and uneven along their whole length; arteries of the 5th and 6th order and veins of the 5-7 orders contracted; the vascular network thickened and there was weak perfusion of the arteries and peripheral portions of the spleen. Group 3: after 2 weeks of hypokinesia the spleen was 1/2 normal size. The inorganic arteries of the 3rd and 4th order showed severe sinuosity. The venous network had thickened greatly. After week 4, the spleen enlarged somewhat. After 6-8 wk, varicose dilitations of the arteries were observed and small arteries remained constricted. Group 4: the walls of the arteries and veins were disrupted.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 64(5): 44-51, 1973

AUTHOR(S): Nesterov, V.P.

EXPERIMENT TITLE: Interrelationship Between Ionic Composition and Functional Activity of Skeletal Muscles in Rats

SUBJECTS: Male Wistar rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Five groups: 1) intact vivarium controls; 2) subjected to 20-day flight in biosatellites, killed 3-10 hr or 25 days after landing, the soleus, phrenicus, and plantaris muscles were excised; 3) subjected to the same conditions of space flight as group 2, except for weightlessness, then killed 3-10 hr, or 25 days after the end of the experiment; 4) hypokinetic in small cages for 30 days then killed, and the soleus, semitendinosus, gastrocnemius, and plantaris muscles were excised; 5) subjected to denervation for 30 days by severing the n.tibial and n.peroneal near the muscles of 1 hind leg. The rats were killed, and the plantaris, extensor digitorum longus and soleus muscles were excised. The muscle tissues from all groups were dried, mineralized, converted into chloride form and analyzed for sodium (Na^+) and potassium (K^+) content. Measurements: content of Na^+ and K^+ in muscle tissue.

IMMOBILIZATION METHOD: Denervation; Cage

RESULTS: Weightlessness induced changes in tissue concentrations of Na^+ and K^+ - increase of the former and decrease of the latter - only in the postural-tonic m.soleus. In m.phrenicus and m.plantaris no significant shifts in tissue concentrations of ions were detected. Hypokinesia and denervation considerably decreased tissue concentrations of K^+ and increased that of Na^+ in fast skeletal muscles; under the same conditions slow m.soleus exhibited simultaneous changes in tissue concentrations of Na^+ and K^+ , although these were less significant.

SOURCE: Zhurnal Evoliutsionnoi Biokhimii i Fiziologii 14(5): 453-460, 1978

AUTHOR(S): Nightingale, T.E., L.H. Littlefield, J.W. Merkley, and J.C. Richardi

EXPERIMENT TITLE: Immobilization-Induced Bone Alterations in Chickens

SUBJECTS: Broiler-type cockerels

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) immobilized. Birds were kept in a standard floor pen. At 1, 4 and 7 wk of age, groups of 6 birds had 1 wing immobilized (half the left wing, half the right wing) for 1-3 wk. At the end of immobilization, birds were killed by cervical dislocation. Measurements: body weight; humerus weight, length, diameter and cortical thickness; bone density; bone breaking strength; individual bone fragment weight.

IMMOBILIZATION METHOD: Body splint

RESULTS: Immobilization significantly reduced humerus bone weight, diameter, cortical thickness, radiographic density and breaking strength; there was no change in bone length, ash, calcium, and phosphorus.

SOURCE: Canadian Journal of Physiology and Pharmacology 52: 916-919, 1974

AUTHOR(S): Nikitin, M.V.

EXPERIMENT TITLE: Effect of Gravitational Acceleration, Hypokinesia And Hypodynamia on the Structure of the Intestinal Vascular Bed

SUBJECTS: 110 Rabbits

AREA OF STUDY: Digestive; Circulatory

OBJECTIVES: To disclose morphological changes in the blood vessels of the small and large intestine under conditions of general hypokinesia and the resulting hypodynamia, of gravitational overload and the combined effect of both.

PROTOCOL: Six groups: 1) 24 rabbits subjected to 1-12 wk hypokinesia in narrow cages; 2) 21 rabbits subjected to gravitational overloads at 9.6 G in various directions; 3) 20 rabbits subjected to unidirectional acceleration then 4-16 wk hypokinesia; 4) 21 rabbits subjected to unidirectional acceleration plus hypokinesia for 4 wk and then 1 additional unidirectional acceleration; 5) same as group 4 but prior acceleration adaptation; 6) 8 controls. The investigative method comprised injection of the animals arterial system with a Herot mass with subsequent stratification of the intestinal wall and clearing, injection of a Hauch roentgenocontrast mass and roentgenography of the intestinal areas.

IMMOBILIZATION METHOD: Cage (narrow)

RESULTS: In early hypokinetic stages blood redistributed causing anorexia, intestinal atonia and secretory disruption. Destructive changes from further exposure included aneurisms, varicoses, extra vascular movement of blood elements, and vascular wall muscle degeneration. The effect of acceleration was greatest in the ventrodorsal direction. Changes due to acceleration followed by hypokinesia were like those due to hypokinesia alone; changes due to acceleration before and after hypokinesia were like those due to acceleration.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii No.3: 54-61, March 1974

AUTHOR(S): Nikitin, M.V.

EXPERIMENT TITLE: Effect of Preliminary Training to Gravitational Stress and Subsequent Exposure to a Series of Extreme Factors on the Intraorgan Blood Circulation Bed of the Intestine

SUBJECTS: 21 Rabbits

AREA OF STUDY: Circulatory; Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) conditioned to gravitational stress according to the following manner: 18 turns in the head-to-tail (+G_z) and chest-to-spine (+G_x) directions, and 9 turns in the tail-to-head direction (-G_z), followed by hypokinesia for 4 wk in cages, then resubjected to the scheduled G-forces. The animals were sacrificed with ether fumes. Measurements: anatomical alterations of the intraorgan circulatory bed of the middle of the small and large intestines.

IMMOBILIZATION METHOD: Cage

RESULTS: Application of cranio-caudal G-forces prior to and following 4 wk of hypokinesia resulted in diverse anatomical reorganization in all of the limbs of the intestine's circulatory bed. Preliminary conditioning of the animals to the maximum tolerable G-forces had a beneficial effect towards the development of anatomical changes occurring during the subsequent application of a series of extreme factors.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 72(4): 44-49, 1977

AUTHOR(S): Nikityuk, B.A. and B.I. Kogan

EXPERIMENT TITLE: Habitus of Growing Inbred Animals Under Conditions of Hypo-, Normo-, and Hyperkinesia

SUBJECTS: August and Wistar rats, 1 mo old; Male mice, 1 mo old male C57Bl/6, CBA, CC57Br/Mv, F₁

AREA OF STUDY: Body mass

OBJECTIVES: In title

PROTOCOL: Three groups of inbred mice and rats: 1) controls; 2) hypokinetic for 2 mo in small cages; 3) hyperkinetic, trained on a treadmill moving at a constant rate of 20 m/min for mice and 30 m/min for rats at increasing duration which reached 60 min/day over a period of 2 mo. Measurements: body mass, skull length, skull width, oblique torso length, length of forelimb to the tip of the elbow, length of the hindlimb, mass of eviscerated carcass and volume of eviscerated carcass.

IMMOBILIZATION METHOD: Cage

RESULTS: Hypo- and hyperkinesia caused a decrease in body mass and specific carcass weight which was more pronounced with hypokinesia. Hypokinesia retarded skeletal growth in front-to-back, vertical and lateral directions, while hyperkinesia stimulated lateral and vertical and retarded front-to-back skeletal growth. Changes in habitus occurring during hypo- and hyperkinesia were found to be genetically determined.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 72(6): 27-31, 1977

AUTHOR(S): Nikityuk, B.A., B.I. Kogan, and S.I. Lominoga

EXPERIMENT TITLE: Adaptation of the Limb Bones of Inbred Rats to Physical Stress Following 60 Days of Hypokinesia

SUBJECTS: 100 Male Wistar and August rats

AREA OF STUDY: Skeletal; Pharmacology

OBJECTIVES: In title

PROTOCOL: Five groups: 1) controls; 2) rats were kept hypokinetic in small cages 23 hr daily for 60 days; 3) kept under same conditions as group 2 plus subjected to running on a treadmill at a constant speed of 30 m/min (3 min the 1st day and increased by 1 min every other day, reaching 30 min at the end of the experiment); 4) kept under same conditions as group 2 plus subjected to running on a treadmill (3 min the 1st day and increased by 1 min every day, reaching 60 min at the end of the experiment); 5) kept under same conditions as group 4, but, also given daily ip injections of phenocoll (0.2 mg/100 gm). Measurements: blood serum calcium and phosphorus content; weight and length of flat and tubular bones.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: During hypokinesia, blood serum calcium and phosphorus content increased and bone growth decreased; these indices were normalized by physical stress and/or phenocoll, depending upon strain membership.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 72(4): 37-43, 1977

AUTHOR(S): Nikityuk, B.A., B.I. Kogan, V.A. Yermol'yev, and L.V. Tindare

EXPERIMENT TITLE: Effect of Graded Physical Load on the State of the Liver from Morphometric Data and Biochemical Blood Indices of Rats Against a Background of Hypokinesia

SUBJECTS: 100 Sexually immature August and Wistar male rats

AREA OF STUDY: Blood; Digestive

OBJECTIVES: In title

PROTOCOL: Five groups: 1) controls; 2) 60 day hypokinesia, 23 hr/day in small restricted cage; 3) hypokinesia and subjected to physical loading on treadmill traveling 30 m/min, increased from 3 to 30 min/day over 60 days; 4) hypokinesia and subjected to physical loading on treadmill, increased from 3 to 60 min/day; 5) hypokinesia and subjected to physical loading on treadmill, increased from 3 to 60 min/day, plus administration of phenamine (.2 mg/100 gm). Experiment lasted 60 days. Animals were then killed, blood was taken, liver excised. Measurements: total blood protein; cholesterol; β -lipoproteins; aldolase activity; blood sugar content; liver glycogen content; liver morphometric data.

IMMOBILIZATION METHOD: Cage

RESULTS: Weight and linear dimensions of the liver decreased in hypokinesia. Total serum protein decreased, aldolase, cholesterol, β -lipoprotein, and blood sugar content rose in hypokinesia. Liver glycogen fell. Animals subjected to physical loading with hypokinesia background had diminished or prevented the effects of hypokinesia. Phenamine aided rehabilitation by physical loading. August rats responded to rehabilitation better than Wistar.

SOURCE: Patologicheskaya Fiziologiya i Eksperimental'naya Terapiya
No.4: 32-35, 1978

AUTHOR(S): Nistico, G. and P. Preziosi

EXPERIMENT TITLE: Brain and Liver Tryptophan Pathways and Adrenocortical Activation During Restraint Stress

SUBJECTS: Adult male Wistar-Morini rats (280-300 gm)

AREA OF STUDY: Nervous; Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) restrained rats. All rats were fasted before treatment. Restraint stress: those which had fasted more than 16 hr were placed in a restraining jacket of fine mesh wire, their paws immobilized with adhesive tape. The jackets were then suspended horizontally by means of rings from a suitable support. The animals were decapitated and blood collected in vessels containing heparin. Samples of blood, liver, and brain were taken 1, 3, 6 and 24 hr after restraint stress. Measurements: corticosterone; brain 5-HT and brain 5-HIAA; liver tryptophan-pyrrolase activity; blood concentrations of endogenous glucocorticoids.

IMMOBILIZATION METHOD: Wire mesh jacket and adhesive tape

RESULTS: The following occurred in rats under restraint as opposed to controls: increase in plasma corticosterone concentration; levels were almost always doubled after restraint stress; increase in liver tryptophan-pyrrolase activity; decrease in brain 5-HT, not correlated with the duration of restraint; decrease in brain 5-HIAA during the first hour followed by a progressive increase up to 24 hr. The 5-HIAA/5-HT ratio increased. During acute restraint stress there was a marked increase in endogenous glucocorticoids.

SOURCE: Pharmacological Research Communications 1(4): 363-368, 1969

AUTHOR(S): Nvota, J., A. Grom, A. Fáberová, D. Lamosová

EXPERIMENT TITLE: Reaction of Chickens to Graduated Length of Exposure to Stress

SUBJECTS: 30 Arbor Acres 60 X Vantress chickens, 60 days old

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Six groups: 1) controls, non-restrained; 2) restrained for $\frac{1}{2}$ hr; 3) restrained for 1 hr; 4) restrained for 2 hr; 5) restrained for 4 hr; 6) administered 5 mouse units of ACTH 1 hr before decapitation. Chickens were immobilized by tying them to a base plate with textile bands. Following decapitation, blood was taken, adrenal glands excised, thyroid glands excised and prepared for microscopy. Measurements: weights of adrenal and thyroid glands; adrenal corticosterone level; blood corticosterone level; the relative contents of epithelium, colloid and stroma in the thyroid gland.

IMMOBILIZATION METHOD: Tied with bands to a base plate

RESULTS: The highest response to immobilization was after $\frac{1}{2}$ hr of restraint, decreasing with increasing length of stress. Adrenal gland weight did not change in any group. Corticosterone in adrenals and blood plasma increased, then decreased after $\frac{1}{2}$ hr; administration of ACTH further increased corticosterone levels. The thyroid glands decreased in weight. Administration of ACTH only slightly decreased thyroid weight. Epithelium contents in the thyroid gland increased after $\frac{1}{2}$ hr immobilization, then decreased. Administration of ACTH only slightly increased epithelium contents.

SOURCE: Biologia 25(11): 797-803, 1970

AUTHOR(S): Nvota, J., D. Lamosova, D. Tesarova, V. Cierna, and P. Vyboh

EXPERIMENT TITLE: Influence of Hypokinesia on Physiological Functions in Fowl

SUBJECTS: Cocks, hybrid Ross 1

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Four groups of 14 animals each: 1) controls; 2) postnatal stress - cocks exposed to stress in their 3rd postnatal wk by being tied down to a supporting plate for 1 hr daily for 5 days; 3) hypokinesia - cocks placed into individual metal cages at 109 days of age for 35 days; 4) postnatal stress plus hypokinesia. Diet: unrestricted amounts of feed mixture. Measurements: body weight; weight of liver, kidneys, heart, m. gastroneus, m. fibularis, thyroid gland, adrenal gland and testicles; serum protein iodine; testosterone and corticosterone levels in plasma; DNA, RNA, protein, glucose, nitrogen, glycogen and fat content in muscles.

IMMOBILIZATION METHOD: Cage (individual metal)

RESULTS: 35 day hypokinesia did not exert any significant influence on physiological functions and body weight growth or on proteosynthesis in the muscles; it accelerated protein metabolism in the muscles. Postincubation stress significantly modified the hypokinesia effect.

SOURCE: Veterinarni Medicina 22(7): 425-432, 1977

AUTHOR(S): Oganov, V.S. and A.N. Potapov

EXPERIMENT TITLE: Functional State of the Skeletal Muscles of Rats
During Prolonged Restriction of Mobility (up to 120
days)

SUBJECTS: 80 Male Wistar rats (170-180 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental rats were placed in close plastic chambers whose volume was increased as the animals grew. Hypokinesia period: up to 4 months. The functional state of the skeletal muscles of the lower leg was investigated each month in 10 control and 10 experimental rats.

IMMOBILIZATION METHOD: Chamber (plastic, size increased as needed)

RESULTS: The depressing effect of hypokinesia on the functional state of the skeletal muscles was manifested in a slowing of the time of development and decrease in strength of the soleus muscle, a decrease in the frequency of fused tetanus and the strength of individual and tetanic responses of the investigated muscles.

SOURCE: Space Biology and Aerospace Medicine 7(2): 29-36, 1973

AUTHOR(S): Orimo, H., T. Fujita, M. Yoshikawa, K. Hayano, and T. Sakurada

EXPERIMENT TITLE: Effect of Estrogen on Immobilization Osteoporosis in Rat

SUBJECTS: 24 Female Wistar rats (6 wk old)

AREA OF STUDY: Endocrine; Skeletal

OBJECTIVES: In title

PROTOCOL: Rats were randomly divided into 4 groups for 6 wk. Groups: 1) controls; 2) right hind limb immobilized in plaster cast; 3) immobilized and given 25 µg daily oral (through stomach tube) dose of conjugated estrogens (Premarin); and 4) immobilization and 100 µg daily dose of Premarin. Casts were changed weekly. At 6 wk blood was drawn from the abdominal aorta and the right femur and tibia were removed. Diet: oriental rat chow; water ad libitum. Measurements: calcium and hydroxyproline content of femur and tibia; cortical thickness of femur; x-ray.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: A marked decrease in the calcium content of the right femur and hydroxyproline content of the right tibia in immobilized rats was significantly inhibited by 100 µg dose of conjugated estrogens. Estrogens also significantly ($p < .05$) protected against the decrease in bone density and cortical thickness of femurs in immobilized rats.

SOURCE: Endocrinology 88(1): 102-105, 1971

AUTHOR(S): Orimo, H., T. Fujita, and M. Yoshikawa

EXPERIMENT TITLE: Effect of Calcitonin on the Development of Immobilization Osteoporosis in Rat

SUBJECTS: 28 Male Wistar-Imamichi rats (200 gm)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Groups: 1) control; 2) untreated rats but with right hind limbs immobilized in plaster casts; 3) immobilization plus daily sc injection of 50 MRCmU porcine calcitonin; 4) immobilization and daily sc injection of 200 MRCmU porcine calcitonin. After 5 wk immobilization and treatment, blood was drawn from the abdominal aorta and the right femur and tibia of each animal were removed and dissected free of soft tissue. Roentgenograms were taken. Diet: oriental rat chow; water ad libitum. Measurements: cortical thickness of femur; serum and tissue calcium; hydroxyline and collagen content of tibia and femur; body weight.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: The final mean body weights of the rats were not significantly different. Percent cortical thickness of the femur of the immobilized rats was markedly smaller than that of controls; porcine calcitonin failed to show any inhibitory effect on this decrease. Serum calcium value of the immobilized rats was slightly but significantly lower than that of controls; the administration of 200 MRCmU of porcine calcitonin caused a slight decrease in serum calcium 24 hr after the last injection. The calcium content of the right femur of immobilized rats was markedly decreased as compared with controls; administration of 50 MRCmU of porcine calcitonin significantly prevented this decrease. Collagen content of the whole tibia was significantly decreased as compared to controls; administration of 200 MRCmU of porcine calcitonin significantly prevented this decrease.

SOURCE: Endocrinologia Japonica 18(1): 117-121, 1971

AUTHOR(S): Orsatti, M.B., L.L. Fucci, J.L. Valenti, and R.C. Puche

EXPERIMENT TITLE: Effect of Bicarbonate Feeding on Immobilization Osteoporosis in the Rat

SUBJECTS: IIM rats (120-130 gm)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Immobilization of the distal half of the rat was achieved by section of the spinal medulla, between the 3rd and 4th lumbar vertebrae, under ether anesthesia. This procedure immobilized 48% of the skeleton. At 3, 8 and 15 days after the operation, rats were killed and selected bones were dissected. Diet: semisynthetic in powder form. Measurements: calcium; magnesium; sodium; potassium; hydroxyproline; citrate; phosphorus.

IMMOBILIZATION METHOD: Cordotomy

RESULTS: Three days postoperation, water content and bone volume were reduced in the femur. 8 days postoperation, there was a significant reduction in hydroxyproline and phosphate content. 15 days postoperation, calcium, magnesium, sodium, citrate, and carbonate were significantly decreased. Bone potassium remained unchanged. Calcium accretion rates and exchange pool sizes were not significantly affected. Sham-operated rats fed a bicarbonate-enriched diet had increased rates of calcium accretion and bone calcium content; bone calcium content increase was not accompanied by phosphate and carbonate content increases. Operated rats fed the same diet had an increased rate of bone resorption.

SOURCE: Calcified Tissue Research 21(3): 195-205, 1976

AUTHOR(S): Osipov, Yu.Yu. and V.S. Shashkov

EXPERIMENT TITLE: Water-Mineral Metabolism in Animals Subjected to Restricted Mobility

SUBJECTS: 20 Male rats (200-250 gm)

AREA OF STUDY: Blood; Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats were placed in specially designed wheeled cages. There were seven series of experiments with a duration from 15 to 90 days; 8-12 rats in each series. Depending on the objectives of the experiment, the animals received a standard diet or a special ration containing all the necessary components, including mineral additives and vitamins. Water consumption was not limited, but in two series the rats received rigorously measured quantities of water (30 ml per day). Measurements: daily urine output; Na and K in the urine and blood plasma; blood hydration; hematocritic index; water content in the whole blood; water and mineral content of tissues and muscles.

IMMOBILIZATION METHOD: Cage (wheeled, volume dependent on size of animals)

RESULTS: The daily quantity of urine for the experimental rats was $1\frac{1}{2}$ to 2 times greater than the control level. There was an increase in the elimination of minerals with the urine during hypokinesia. Despite the loss of minerals and fluid with the urine, the electrolyte composition of the blood plasma remained virtually unchanged. The water content in the tissues of internal organs of rats killed during the 30th and 68th days of hypokinesia was reduced by 0.2-0.5%; in the skin by 2%. In the flexor and extensor muscles of the lower leg on the 62nd day of hypokinesia there was an increase of 8-12% in the sodium and potassium levels.

SOURCE: Space Biology and Aerospace Medicine 7(1): 25-31, 1973

AUTHOR(S): Palazhchenko, E.F.

EXPERIMENT TITLE: Effect of Gravitation Stress and Hypokinesia on
Blood Vessels of the Testicle

SUBJECTS: 110 Male rabbits (2.4-2.8 kg)

AREA OF STUDY: Circulatory; Endocrine

OBJECTIVES: In title

PROTOCOL: Three series of experiments: 1) 30 rabbits, 1 maximum endurable stress of a cranio-caudal direction on a centrifuge with platform radius of 1 m for 12.5 min; 2) 40 rabbits, hypokinesia in close cages for 1, 2, 4, 6 and 8 wk; 3) 40 rabbits, centrifugal stress after hypokinesia. After the end of the experiments the animals were killed. Histological and x-ray technique were used in vessel examination.

IMMOBILIZATION METHOD: Cage (close)

RESULTS: The stresses caused dilation of the vessels, greater sinuosity, uneven contours and ruptures of the walls and extravasation. Hypokinesia caused an increasing atrophy of the testis. Hypokinesia followed by stress resulted in pronounced lesions in all the links of the vessel bed of the testicle such as deformation of the vessels and of the wall structure.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 64(5): 57-63, 1973

AUTHOR(S): Parin, V.V., B.M. Fedorov, and V.S. Nevstruyeva

EXPERIMENT TITLE: Changes in Corticosteroid and Catecholamine Metabolism
After Sharp Limitation of Motor Activity

SUBJECTS: 32 Male rabbits (3-4 kg)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 16 controls; 2) 16 rabbits immobilized in cages. The rabbits were sacrificed 11-12 and 30 days after the start of the experiment by exsanguination. Measurements: 11-oxycorticosteroids in blood plasma, norepinephrine and epinephrine in the adrenals, myocardium, and hypothalamus.

IMMOBILIZATION METHOD: Cage (wire)

RESULTS: Twelve days of hypokinesia decreased oxycorticosteroids in peripheral blood plasma, decreased norepinephrine in the myocardium and hypothalamus; epinephrine content was unchanged in the heart, decreased insignificantly in the adrenals and changed slightly in the hypothalamus. By day 30, norepinephrine of the myocardium decreased further, and was partly restored in the hypothalamus. Epinephrine content of the adrenals was less than half of the controls; decreased more moderately in the myocardium and hypothalamus.

SOURCE: Doklady Akademii Nauk SSSR 184(1): 250-251, 1969

AUTHOR(S): Parízková, J. and R. Poledne

EXPERIMENT TITLE: Consequences of Long-Term Hypokinesia as Compared to Mild Exercise in Lipid Metabolism of the Heart, Skeletal Muscle and Adipose Tissue

SUBJECTS: Male Wistar rats

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Rats were studied from birth until 90 and 150 days of age, subdivided according to the degree of physical activity into 3 groups: 1) control; 2) exercised; and 3) hypokinetic. Hypokinetic rats were placed in small chambers after weaning, i.e. the 30th day. Free fatty acid (FFA) distribution was studied by injected albumin-bound palmitate- ^{14}C and albumin- 131 . Diet: Larsen mixture. Measurements: FFA in soleus and heart muscles; body fat; lipids; body weight; caloric intake.

IMMOBILIZATION METHOD: Chamber with wire net walls

RESULTS: Hypokinetic animals were characterized by the lowest caloric intake in both age groups, and the reverse applied to the exercised rats. In the younger age group, the total body weight was significantly highest in controls as compared with exercised and hypokinetic animals. In the 150-day-old group hypokinetic rats achieved the highest values of total body weight, and exercised rats had the lowest body weight. The development of fat-free body weight was reduced due to hypokinesia in 90-day-old, but was the same in all 150-day-old animals. The percentage of fat in the hypokinetic rats did not differ from controls, and was significantly reduced in the exercise animals. FFA and inflow-outflow rate of palmitate- ^{14}C at rest was significantly lowest in hypokinetic rats. Palmitate- ^{14}C inflow was always higher to the adipose tissue and lower to the soleus and heart muscles in hypokinetic rats; the reverse was true for exercised rats even at rest. Palmitate- ^{14}C inflow to the soleus and heart muscles of hypokinetic rats was significantly lower than in exercised rats; the reverse was found in adipose tissue.

SOURCE: European Journal of Applied Physiology 33: 331-338, 1974

AUTHOR(S): Paul, M.I., R. Kvetnansky, H. Cramer, S. Silbergeld, and I.J. Kopin

EXPERIMENT TITLE: Immobilization Stress Induced Changes in Adrenocortical and Medullary Cyclic AMP Content in the Rat

SUBJECTS: Male Sprague-Dawley rats (180-250 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Three groups: 1) hypophysectomized rats were administered ACTH (5 IU sc) daily for 7 days, then restrained; 2) sham-hypophysectomized, administered theophylline (60 mg/kg 30 min) before immobilization; 3) left adrenal gland denervated by severing of left splanchnic nerve, contralateral side as control 3 days before restraint. All animals were immobilized by inserting their heads through 2 parallel concentric steel wire loops fixed on a metal plate and fastening their limbs to 4 mounted metal strips with adhesive tape for either 5, 10, 30 or 150 min, or for 2.5 hr daily for 1-40 days. After decapitation, adrenal glands were removed, cleaned, weighed and homogenized in perchloric acid containing tritiated cyclic AMP. In 2 experiments, the adrenal medulla was separated from the cortex, homogenized and assayed. Measurements: level of cyclic AMP.

IMMOBILIZATION METHOD: Steel wire loops on metal plate

RESULTS: After 30 min of immobilization, adrenal cyclic AMP rose significantly, returning to baseline levels after 150 min. Theophylline pretreatment shifted the maximal cyclic AMP increase after restraint to 10 min; baseline return took 30 min. Repeated immobilization had no effect on the 30 min cyclic AMP peak during immobilization. Hypophysectomy blocked the adrenal cyclic AMP rise and caused a small but significant decrease of AMP after 10 or 30 min of restraint. Adrenal denervation did not alter cyclic AMP in the controls, but reduced the elevation to 50% of the response seen in the intact adrenals of stressed rats. There was no increase in cyclic AMP in the adrenal medulla after stress, but there was a highly significant cortical increase in cyclic AMP after immobilization. Cyclic AMP increased in the adrenal cortex of denervated animals, but not in the medulla.

SOURCE: Endocrinology 88: 338-344, 1970

AUTHOR(S): Paul, M.I., R. Kvetnansky, H. Cramer, S. Silbergeld, and I.J. Kopin

EXPERIMENT TITLE: Immobilization Stress Induced Changes in Adrenocortical and Medullary Cyclic AMP Content in the Rat

SUBJECTS: Male Sprague-Dawley rats (180-250 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Immobilization: varying in Experiment 1; 2.5 hr daily for a varying number of days in Experiment 2. Animals were immobilized by inserting their heads through 2 parallel concentric steel wire loops and fastening their limbs to 4 mounted metal strips with adhesive tape. Pretreatment: 5 IU/day ACTH gel was injected sc for 7 days into hypophysectomized rats beginning the 2nd day postoperation with the last injection given 24 hr preimmobilization. Sham-operated rats received 60 mg/kg theophylline ip 30 min preimmobilization. Some rats were adrenalectomized on the left side 3 days preimmobilization. Rats were decapitated while immobilized; adrenal glands were removed. Measurements: adrenal cyclic AMP (cAMP) in adrenal cortex and medulla.

IMMOBILIZATION METHOD: Steel wire loops, metal strips and adhesive tape

RESULTS: After 30 min of restraint, there was a highly significant rise in whole adrenal cAMP, returning to baseline after 150 min. Theophylline shifted the maximal cAMP increase after restraint to 10 min, with baseline return at 30 min. Hypophysectomy blocked adrenal cAMP rise; there was a small but significant decrease after 10 or 30 min of restraint. Adrenal gland denervation did not affect cAMP levels in unstressed rats but reduced the elevation to about 50% of the response seen in intact adrenals of stressed rats. There was no increase in cAMP in the adrenal medulla after stress although the medullary component of cAMP was 50% of the total. There was a highly significant cortical increase in cAMP postrestraint. There was also a significant increase in adrenocortical cAMP in denervated adrenals of stressed rats but not in the medulla.

SOURCE: Endocrinology 88: 338-344, 1971

AUTHOR(S): Pavlik, G. and R. Frenkl

EXPERIMENT TITLE: Effect of Immobilization on the Catecholamine - and Histamine-Induced Responses of Blood Pressure and Pulse Rate in Rats Adapted to Swimming and in Controls

SUBJECTS: Female Wistar rats (210-260 gm)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 11 rats were made to swim for 60-120 min daily with a load of 4 gm/100 gm body weight for 10-12 wk; 2) 10 controls. The jugular vein and 1 of the carotids were then cannulated under ether anesthesia and the rats covered with plaster except for the head and limbs. During immobilization, histamine (25-100 μ g/kg) or isoproterenol (0.5-2.0 μ g/kg) or noradrenaline (0.5-2.0 μ g/kg) were administered. Measurements: blood pressure; pulse rate.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: Blood pressure remained stable immediately after immobilization but fell abruptly to a lower level after 1.5-3.5 hr. The pulse rate showed a time-related exponential decline which was less in the rats adapted to swimming. The amplitude of the response to noradrenaline increased during 4 hr immobilization while the histamine and isoproterenol-induced responses showed no time related changes. There were no differences between the groups for noradrenaline and histamine while the isoproterenol-induced responses differed also during immobilization.

SOURCE: Acta Medica Academiae Scientiarum Hungaricae 35(3-4): 331-338, 1978

AUTHOR(S): Pavlova, M.N., A.I. Volozhin, and I.Sh. Muradov

EXPERIMENT TITLE: Effect of Hypokinesia on Structure and Mineral Content of the Long Bones in Puppies

SUBJECTS: 6 Noninbred puppies (2 mo old)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 3 experimental puppies; 2) 3 control. Experimental animals were placed in cages for 2 months. Experimental group then killed; their humeri, femora and tibiae removed and x-rayed; roentgenograms and the MBS-2 microscope were used for examining bones. Measurements: length of bones; external diameter, thickness of the cortical layer on the anterior and posterior surfaces of the bone; width of the medullary canal; area of cross section of the whole bone and of the cortical layer of the diaphysis.

IMMOBILIZATION METHOD: Cage (45 x 45 x 45 cm)

RESULTS: A relative decrease in the volume and relative thickness of the cortical layer of the bone was found. Active resorption of the Haversian canals occurred accompanied by the formation of many irregularly shaped multinuclear giant osteoclasts. Mineral saturation showed a tendency to decrease in the femur and tibia. The cortical layer became thinner but the medullary canal of the long bones became longer relative to their external diameter.

SOURCE: Bulletin of Experimental Biology and Medicine 80(8): 892-895, 1975

AUTHOR(S): Peacock, E.E., Jr.

EXPERIMENT TITLE: Comparison of Collagenous Tissue Surrounding Normal and Immobilized Joints

SUBJECTS: 8 Mongrel dogs

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: One hind limb was immobilized in flexion with an extra-articular Steinmann pin. After 4 wk of immobilization specimens of fibrous tissue were excised from the patellar tendon, soleus fascia, popliteal connective tissue, and external collateral ligament of the contracted joint and the contralateral normal joint. Measurements: the gross thermal shrinkage (Ts) temp and Ts of individual fibers.

IMMOBILIZATION METHOD: Extra-articular Steinmann pin

RESULTS: At the fiber level there were apparently fewer and/or weaker heat sensitive crosslinks than in fibers from the control joints. The marked increase of collagen in the loose connective tissue from the popliteal space indicated that new collagen production even after 4 wk of immobilization was responsible for the clinical finding of decreased range of motion.

SOURCE: Surgical Forum 14: 440-443, 1963

AUTHOR(S): Pellegrino, C. and C. Franzini

EXPERIMENT TITLE: An Electron Microscope Study of Denervation Atrophy
in Red and White Skeletal Muscle Fibers

SUBJECTS: Adult albino rats (100-300 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: The entire right rear leg was denervated by removing 1 cm of the sciatic nerve. The left, intact leg served as control. At intervals of 8, 15, 30 and 60 days after denervation, the soleus and gastrocnemius muscles were removed and weighed. The muscles were then prepared for both light and electron microscopy. Measurements: muscle fiber diameters; muscle weight; changes in cytoplasmic ultrastructure.

IMMOBILIZATION METHOD: Denervation

RESULTS: Two major phases of atrophy were found which overlapped in time. In the first, a degenerative autolytic process took place in areas of the fiber, with loss of striation. It could be detected as early as the 7th day, with the maximum at the 14th day and accounts for a weight loss of 50%. The first alteration appeared in the Z lines, disorder in the disposition of filaments followed. This process occurred rapidly, leaving large areas in the cell in which only ground substance, glycogen, rare randomly disposed vesicular elements and some mitochondria could be found. Several lysosomes and masses of lipoproteins were found in the fibers, and large parts of the sarcoplasm were discarded into the intercellular spaces. The second phase of atrophy was detectable after 1 mo. Single myofibrils underwent different degrees of reduction in diameter, while the spatial disposition of primary and secondary filaments inside the fibrils remained normal. The sarcoplasmic reticulum was still preserved, and relatively overdeveloped mitochondria disappeared in parallel with the contractile material.

SOURCE: Journal of Cell Biology 17: 327-349, 1963

AUTHOR(S): Petrova, N.V. and V.V. Portugalov

EXPERIMENT TITLE: Lactate Dehydrogenase Isozymes of Rat Skeletal Muscles
Following a Space Flight and With Hypokinesia

SUBJECTS: Male rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Four groups: 1) 22-day orbital flight (examined on day 2 or 27 post-flight); 2) ground-based model experiment (examined on day 2 or 27 post-experiment); 3) hypokinesia in box cages for 7, 15, 36 and 60 days; 4) controls. Measurements: isozyme composition of lactate dehydrogenase (LDH) from soleus and plantaris muscles.

IMMOBILIZATION METHOD: Cage (box)

RESULTS: After 22 days of weightlessness, the activity of LDH₁ and LDH₂ diminished and that of LDH₄ and LDH₅ increased. Morphological studies revealed atrophy and dystrophy of the soleus muscle fibers. The ground-based experiment did not lead to any appreciable changes in soleus metabolism. The changes in LDH activity, spectrum, and muscle morphological changes were similar for the hypokinetic and orbital flight groups.

SOURCE: Space Biology and Aerospace Medicine 11(5): 80-87, 1977

AUTHOR(S): Pevzner, L.Z., L. Venkov, and L. Cheresarov

EXPERIMENT TITLE: Effects of Motor Patterns on Water-Soluble and Membrane Proteins and Cholinesterase Activity in Subcellular Fractions of Rat Brain Tissue

SUBJECTS: Male Wistar rats, 60 days old

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Four groups: 1) controls; 2) animals trained 6 days/week on a moving track for 1 hr daily; 3) animals kept in restraint cages but not completely immobilized; 4) controls. After 380 days, the brains were removed, homogenized, and fractions prepared. Measurements: myelin, synaptosome, mitochondria, and microsome.

IMMOBILIZATION METHOD: Cage (individual cupola-shaped cages)

RESULTS: Increased motor activity resulted in a rise in acetylcholinesterase activity while hypokinesia induced a pronounced decrease in this enzyme activity. The butyrylcholinesterase activity somewhat decreased after hypokinesia but did not change under the motor load pattern. Motor load caused an increase in the amount of synaptosomal water-soluble proteins possessing an intermediate electrophoretic mobility and seemed to correspond to the brain specific protein 14-3-2. In the synaptosomal fraction the amount of membrane proteins with low electrophoretic mobility and with the cholinesterase activity rose. Hypokinesia decreased the amount of these membrane proteins.

SOURCE: Ukrainskii Biokhimicheskii Zhurnal 50(1): 20-24, 1978

AUTHOR(S): Pfeiffer, C.J.

EXPERIMENT TITLE: The Physiologic Effects of Restricted Activity in the Rat: Stress Effects of Chronic Restraint

SUBJECTS: 543 Adult and weanling Sprague-Dawley rats

AREA OF STUDY: Metabolism and Energy Exchange; Digestive

OBJECTIVES: In title

PROTOCOL: Effects of restraint compared with respect to: 1) fasted vs nonfasted; 2) age (adult vs weanling); 3) length of restraint (5 days vs 5 wk). At the termination of each experiment, all rats were sacrificed by intracranial injection of ethanol, and were autopsied immediately. The stomachs and duodena were opened and examined for ulceration and hemorrhage, and the thymus, adrenal glands, and testes were removed and examined. Measurements: mortality; growth; incidence of gastrointestinal ulceration; organ weights.

IMMOBILIZATION METHOD: Cage

RESULTS: Zero mortality rates were observed for both restraint and non-restraint treatments with the exception of 2 experiments: mortality rates of 28 and 21% were observed for weanling rats subjected to 5 days of restraint and fasting, and 5 days of fasting without restraint, respectively. Growth curves of both weanling and adult rats restrained for 5 wk were slightly depressed. Fasting induced ulceration in both restrained and non-restrained adult; no ulceration in rats fed ad libitum. The adrenal weights of fasted, restrained rats were significantly smaller than in nonrestrained rats. There were no other significant organ weight responses to restraint. The mean weight loss was significantly less in restrained, fasted rats than in non-restrained, fasted rats.

SOURCE: Experimental Medicine and Surgery 25(2-4): 201-217, 1967

AUTHOR(S): Platonova, R.D., G.M. Baskakova, and S.A. Chepurnov

EXPERIMENT TITLE: Change in Blood Glucose Level in Rats After Immobilization

SUBJECTS: 25 Male white rats (175-200 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Four groups, each group immobilized for 3 hr 40 min on a restraint board: Group 1) blood glucose level determined immediately after immobilization; Groups 2, 3, 4) after 2 hr immobilization, the blood glucose level measured every 20 min for 3 hr 40 min. In 1 group desoxycorticosterone (5.7 mg/kg ip) was administered over 4 days before the start of the experiment. Measurements: blood glucose.

IMMOBILIZATION METHOD: Board

RESULTS: Preliminary immobilization for 2 hr negated the increase in the blood glucose caused by the stress reaction. By the 2nd hr of immobilization in the presence of continuing stress the blood glucose level stabilized and varied within 42 ± 5.5 and 47 ± 8.1 mg %. Within 2 hr after the immobilization, the differences in the blood glucose level of the animals from the control groups were statistically insignificant.

SOURCE: Biologicheskije Nauki 18(9): 37-40, 1975

AUTHOR(S): Pliskovskaya, G.N., A.L. Germanova, N.G. Ivanov, Ye.A. Il'in, V.M. Milyavskiy, and A.D. Noskin

EXPERIMENT TITLE: Measurement of the Ammonia Content in the Atmosphere of Biosatellite Mock-Ups and Its Standardization

SUBJECTS: 120 Male rats (220-250 gm)

AREA OF STUDY: Respiratory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 60 control rats; 2) 60 experimental rats were placed in individual restrictive cages limiting their movements for 30 days. Then both groups of animals were ammonia poisoned (4-hr exposure) by the dynamic method in 200-liter chambers to determine ammonia's toxic effects. In a 2nd experiment, atmospheric formation was studied by placing 45 rats in separate pressurized chambers with life support systems. Measurements: respiration; pulmonary tissue; cell reaction of the lungs and upper respiratory passages; sensitivity of olfactory analyzer; functional state of the nervous system; rectal temperature; orientation reaction; spontaneous motor activity.

IMMOBILIZATION METHOD: Cage

RESULTS: Hypokinesia increased rat sensitivity to ammonia; the threshold of the irritating effect decreased by a factor of two. An ammonia concentration of 243 mg/m^3 caused a change in the specific and integral indices. There was a change in the respiration rate, acuteness of the sensation of smell, summation of threshold index, and also an increase in the number of cell elements in wash water from the mucous membrane of the upper respiratory passages.

SOURCE: Space Biology and Aerospace Medicine 9(2): 43-50, 1975

AUTHOR(S): Pohoska, E., H. Kaciuba-Uscilko, and Z. Brzezinska

EXPERIMENT TITLE: Reaction to Cold in Immobilized Rats

SUBJECTS: 20 Male Wistar rats (200-260 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 10 rats were immobilized in plastic cages for 3 wk; 2) 10 controls kept in metabolic cages for the same period. The animals were then exposed to cold ($13 \pm 1^{\circ}\text{C}$) for 24 hr. Measurements: oxygen uptake; rectal temperature; urinary adrenaline and noradrenaline; free fatty acid, lactate and pyruvate concentrations in the blood; adrenaline and noradrenaline in the adrenal gland.

IMMOBILIZATION METHOD: Cage (plastic)

RESULTS: Exposure of both control and immobilized rats to cold resulted in a marked increase of O_2 consumption. In the immobilized rats it was accompanied by a decrease and in the controls an increased rectal temperature. Blood lactate and pyruvate decreased in the immobilized animals and increased in the controls. In both the immobilized and control rats the urinary catecholamine excretion and adrenomedullary catecholamine content changed in the same direction during cold exposure but significant differences between the two groups were found.

SOURCE: Bulletin de l'Academie Polonaise des Sciences. Serie des Sciences Biologiques 23(8): 555-558, 1975

AUTHOR(S): Pohoska, E., H. Kaciuba-Uscilko, L. Tomaszewska, and S. Kozlowski

EXPERIMENT TITLE: Metabolic Changes During Prolonged Immobilization of Rats. Role of Catecholamines

SUBJECTS: 40 Male Wistar rats (200-270 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Three series of experiments: 1) consisted of 2 groups - 10 controls kept in metabolic cages and 10 experimental rats immobilized in plastic cages for 3 wk; 2) 1 group of 10 rats exposed to hypokinesia for 3 wk and injected sc with exogenous noradrenaline in a dose of 100 µg/100 gm of body weight; 3) 1 group of 10 rats exposed to hypokinesia for 3 wk and injected sc with propranolol in a dose of 6 mg/kg body weight. Measurements: oxygen uptake; rectal temperature; free fatty acid, lactate and pyruvate levels in the blood; urinary adrenaline and noradrenaline; adrenal catecholamine; body weight.

IMMOBILIZATION METHOD: Cage (plastic)

RESULTS: Immobilization for 3 wk caused a decrease in body weight, an increase of O₂ uptake and no significant temperature change. Blood lactate and pyruvate concentrations increased while plasma FFA concentrations were not altered. Adrenal content was lowered while noradrenaline content was not altered. Noradrenaline-induced increases in O₂ consumption were reduced by the end of 3 wk immobilization. Propranolol injected to the immobilized rats reduced their metabolic rate to the initial pre-immobilization value.

SOURCE: Bulletin de l'Academie Polonaise des Sciences. Serie des Sciences Biologiques 23(8): 559-563, 1975

AUTHOR(S): Pokrovskiy, A.A., R.A. Zavalishina, and A. Menendes

EXPERIMENT TITLE: Investigation of Disturbances in Mineral Metabolism
in Rats During Prolonged Hypokinesia

SUBJECTS: 160 Male Wistar rats (200 gm)

AREA OF STUDY: Skeletal; Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental rats were placed in special plexiglas cages. Animals were killed on the 15th, 30th, 60th and 90th days of the experiment. Urine and feces were collected at this time. In the urine, sodium, magnesium inorganic phosphorus, citric acid and hydroxyproline was determined. In the hip bones, feces, and also in the diet after reduction to ash, calcium and phosphorus, and in the tibial bones, citric acid and hydroxyproline was determined.

IMMOBILIZATION METHOD: Cage (plexiglas)

RESULTS: Urine electrolyte excretion exhibited three phases. The first two phases were typical of two stages in the stress period. The third phase was characterized by a normal excretion of potassium and magnesium and an increased excretion of calcium and phosphorus up to 150-170% by the end of the experiment. Balance studies indicated higher losses of calcium and phosphorus equilibrium remaining positive. Impairment was found in both the mineral composition and organic compounds of the bone tissue.

SOURCE: Space Biology and Aerospace Medicine 8(4): 11-17, 1974

AUTHOR(S): Popkov, V.L., E.S. Mailyan, Yu.S. Galushko, Ye.A. Kovalenko, Ye.I. Zaytseva, I.A. Nitochkina, L.V. Smulova, and A.V. Ryazhskiy

EXPERIMENT TITLE: Changes in the Gas Metabolism, Gas Homeostasis and Tissue Respiration in the Rat During Prolonged Hypokinesia

SUBJECTS: 78 White rats

AREA OF STUDY: Respiratory; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 30 controls; 2) 48 experimental rats in restricting cages where they were kept under conditions of fixed posture for 60 days. The overall gas metabolism was determined by the closed chamber method. After the rats were placed for 1 hr in a sealed chamber, the average sum consumption of oxygen, liberated carbon dioxide gas, and the respiratory coefficient were determined according to the final chemical composition of the air. The intratissue pressure of oxygen (pO_2) and carbon dioxide were determined according to the tissue depot method. Intensity of tissue respiration was determined on the 45th and 69th days of hypokinesia in sections of tissue of the cerebral cortex, heart, liver, and skeletal muscle. At the end of the 60-day experiment, determination was made of the maximum physical working capacity tested by maximum swimming time of all rats. The relationship of free and phosphorylation oxidation was studied.

IMMOBILIZATION METHOD: Cage (restricting)

RESULTS: Among the white rats kept in confining cages, the overall gas metabolism and intratissue gas homeostasis did not significantly change over the course of the 60-day long experiment period. However the intensity of respiration of certain tissues changed: in the liver it increased, in the myocardium it decreased. The relationship of free and phosphorylation oxidation in the experimental remained the same as in the control. There was a sharp decrease in the experimental animals' physical endurance. The 60-day long period of hypokinesia caused retarded growth of the animals.

SOURCE: Fiziologicheskii Zhurnal SSSR Imeni I M Sechenova 56(12): 1808-1812, 1970

AUTHOR(S): Poppei, M. and K. Hecht

EXPERIMENT TITLE: The Effect of Repeated Restrictions of Motor Activity
Upon Systolic Blood Pressure of Albino Rats

SUBJECTS: Rats

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) immobilized in folding plastic tubes for periods of 1-20 hr per day for 7.5 mo. The duration and arrangement of the immobilization phases of several wk and the intervening pauses were random; 2) controls. Measurements: systolic blood pressure was taken at least 4 hr after immobilization.

IMMOBILIZATION METHOD: Plastic tube

RESULTS: With increasing duration of restraint, systolic blood pressure readings from 114 to 146 Torr with a high of 240 were obtained. Blood pressure remained high (134 Torr) for 5 wk following the experiment.

SOURCE: Acta Biologica et Medica Germanica 27: 297-306, 1971

AUTHOR(S): Poppei, M., K. Hecht, and V. Moritz

EXPERIMENT TITLE: Integrative Activity of the Brain and Blood Pressure in Rats During Hypokinetic Stress

SUBJECTS: Male Wistar rats

AREA OF STUDY: Nervous; Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinetic in plastic tubes for 1, 3, 8 and 15 wk. Measurements: blood pressure; number of positive responses to conditioned reflex stimuli.

IMMOBILIZATION METHOD: Plastic tube

RESULTS: The effect of hypokinesia during the initial period showed a slowdown of the conditioned reflex formed which preceded changes in blood pressure. At 3 wk, capability for learning increased through acceleration in developing habits and good correlation between the latent period of the reflex and the time of the motor reaction. After 6 wk, capability for learning decreased. Blood pressure increased overall from 118 mm Hg at the start of the testing to 130 mm Hg at the end.

SOURCE: Zhurnal Vysshei Nervnoi Deiatelnosti 27(2): 348-349, 1977

AUTHOR(S): Popper, C.W., C.C. Chiueh, and I.J. Kopin

EXPERIMENT TITLE: Plasma Catecholamine Concentrations in Unanesthetized Rats During Sleep, Wakefulness, Immobilization and After Decapitation

SUBJECTS: Male Sprague-Dawley rats, 50-100 days old (250-450 gm)

AREA OF STUDY: Behavior; Endocrine

OBJECTIVES: In title

PROTOCOL: Pre-experimental implantation of chronic indwelling arterial catheters or cannulae permitted the collection of blood samples. Five groups: 1) sleep - 6 rats, considered to be asleep when they had been immobile with eyes closed for at least 3 min, with normal muscle tone and quiet respiration; 2) wakefulness - 6 rats, eyes open for at least 3 min; 3) handled - 6 rats, lifted by tail so that front paws could barely touch floor of the cage, with blood samples obtained beginning 30 sec after the rat had been held in that position for 30 sec. All subjects were examined 5-10 days after surgery, and 3 blood samples were obtained; 4) immobilization - 4 rats, legs were taped to clips on a metal plate, blood samples obtained after 5 min of immobilization; 5) decapitation - 3 unanesthetized rats without cannulae; blood obtained from severed neck. Measurements: plasma levels of catecholamines (CA): norepinephrine (NE), epinephrine (EPI).

IMMOBILIZATION METHOD: Tape, clips, metal plate

RESULTS: During physiological sleep, the plasma concentration of NE was about twice that of EPI. Compared with animals in natural sleep, awake rats had increases in plasma levels of EPI but larger, significantly higher levels of NE. Handling resulted in a significant increase in EPI (75% increase), but only a small increase in NE levels. Immobilization produced massive elevations of circulating levels of both EPI and NE. Decapitation was associated with a 10-fold increase in circulating NE and an 80-fold increase in circulating levels of EPI.

SOURCE: Journal of Pharmacology and Experimental Therapeutics 202(1): 144-148, 1977

AUTHOR(S): Portugalov, V.V., O.G. Gazenko, Ye.I. Il'ina-Kakuyeva, V.B. Malkin, T.V. Artyukhina, I.A. Bukayeva, V.Ya. Gotlib, K.D. Rokhlenko, N.A. Roshchina, and B.I. Starostin

EXPERIMENT TITLE: Some Effects Developing During Hypokinesia (Experiments on Mice)

SUBJECTS: 161 White mice (Balb/C line)

AREA OF STUDY: Muscular; Nervous

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 71 experimental mice; 2) 90 control. The experimental mice were placed in very small pens for 30 days. Physiological, cytochemical, histological and electron microscope methods were used to study the condition of voluntary muscles, and of certain cell formations of the nervous system, suprarenals, thyroid, liver, etc.

IMMOBILIZATION METHOD: Pen

RESULTS: During the first few days of hypokinesia most of the experimental animals exhibited stress reactions. There was an increase in motor activity; the animals strove to free themselves. After 2 to 4 days the animals became accustomed to their living conditions. There was less activity; the mice spent a lot of time dozing and sleeping. By the 15th day changes caused by hypokinesia itself were manifested. Weight loss had reached 22.3%. There was intensification of atrophy in the thymus and spleen. The hepatic cell glycogen content had decreased sharply. The condition of nerve cells of neurosecretory nuclei in the hypothalamus indicated a further increase in their function. Changes in RNP content in intervertebral ganglia neurons and spinal cord motor neurons were less sharply expressed. Atrophic changes appeared in the striated muscles of the rear extremities particularly in the quadriceps femoris muscle. There was an increased number of mitochondria and increased density crist packing within them. By the 30th day of hypokinesia, the changes were less distinct than during the earlier stages in the experiment.

SOURCE: Space Biology and Aerospace Medicine 1(6): 24-34, 1967

AUTHOR(S): Portugalov, V.V., Ye.I. Il'ina-Kakuyeva, T.V. Artyukhina, V.Ya. Gotlib, and V.I. Starostin

EXPERIMENT TITLE: Changes in Certain Endocrine Glands and Hypothalamic Secretory Nuclei During Hypokinesia

SUBJECTS: 110 Male white rats (160-180 gm)

AREA OF STUDY: Endocrine; Nervous

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinetic in special small cages for 1, 3, 5, 10, 14, 20, 30, 45 and 60 days. Histological and cytochemical methods were used to study the large-celled hypothalamic nuclei, the posterior lobe of the hypophysis, the adrenals, the thyroid, the thymus, and the spleen. Body weight was also measured.

IMMOBILIZATION METHOD: Cage

RESULTS: The initial acute phase (1-5 days), during which the endocrine glands worked under maximum load, was followed by a period of adaptation. No morphological changes in any of the structures studied (except the thymus) were observed after 45-60 days although the weight of the adrenals remained elevated until the end of the experiment. There was a decrease in body weight of the hypokinetic rats.

SOURCE: Eksperimental'nye Issledovaniya Gipokinezii, Izmenennoi Gazovoi Sredy, Uskorenii, Peregruzok i Drugikh Faktorov (ed. by V.V. Parin et al), 1968, pp. 29-33.

AUTHOR(S): Portugalov, V.V., Ye.I. Il'ina-Kakuyeva, V.I. Starostin,
I.A. Bukayeva, and V.I. Lobachik

EXPERIMENT TITLE: Cytochemical Study of Striated Muscles During Hypokinesia
(Experimental Investigation)

SUBJECTS: Rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinetic in cages for 1-60 days. Cytochemical methods were employed to study certain aspects of the metabolism of the hind-leg muscles (soleus, gastrocnemius, and quadriceps). Measurements: activity of dehydrogenases associated with NAD (inosinate, malate, β -oxybutyrate, isocitrate, α -glycerophosphate; activity of dehydrogenases associated with NADP (malate); activity of dehydrogenases not associated with coenzymes (succinate dehydrogenase, α -glycerophosphate dehydrogenase); transglycosylase activity (phosphorylases A and B, UDPH-glycogen synthetase); glycogen and fat content.

IMMOBILIZATION METHOD: Cage

RESULTS: Of the 3 muscles studied, the greatest changes were detected in the soleus during hypokinesia. There was an increase in β -oxybutyrate, UDPH, and α -glycerophosphate, and a decrease in fat content. Glycogen accumulated in the muscle fibers of the soleus from the early stages of the experiment. The changes in oxidative-enzyme activity in the thin fibers of the gastrocnemius and quadriceps were substantially less pronounced than the similar changes in the fibers of the soleus. The behavior of the same enzyme often differed in thick and thin fibers; there was a decrease in the activity of a number of enzymes in the thick fibers of both the gastrocnemius and quadriceps on day 14 of the experiment, while their activity increased in the thin fibers. There was a decrease in phosphorylase activity and a concomitant drop in glycogen content in the thick fibers of the gastrocnemius and quadriceps from the 10th day of the experiment on. The intermediate fibers and some of the thin fibers exhibited a substantial increase in glycogen content and UDPH activity, while their fat content decreased.

SOURCE: Eksperimental'nye Issledovaniya Gipokinezii, Izmenennoi Gazovoi Sredy, Uskorenii, Peregruzok i Drugikh Faktorov (ed. by V.V. Parin et al), 1968, pp. 25-28.

AUTHOR(S): Portugalov, V.V. and K.D. Rokhlenko

EXPERIMENT TITLE: Electron-Microscopic Studies of Striated Muscles During Hypokinesia

SUBJECTS: Male rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinetic in restraint cages for 1-60 days. Specimens of the soleus, gastrocnemius, and quadriceps muscles were taken from 2 experimental and 2 control rats on days 1, 5, 14, 30, 45 and 60 of the experiment.

IMMOBILIZATION METHOD: Cage

RESULTS: Changes occurred in both the red and composite skeletal muscles of the hypokinetic rats from the 1st day of the experiment. The early signs of changes in the red muscles took the form of edema and severe mitochondrial destruction. Disruptions of the contractile apparatus were also noted in composite muscles. Longer periods of hypokinesia caused the dystrophic changes in the myofibrils to become more severe and extensive, the fibrils were reduced, there was a relative increase in the volume of sarcoplasm, and a large number of membranes resembling the Golgi apparatus in organization appeared. Glycogen content increased throughout the experiment, while fat content (in the soleus) decreased. There was a pronounced tendency toward connective-tissue proliferation, especially in the soleus.

SOURCE: Eksperimental'nye Issledovaniya Gipokinezii, Izmenennoi Gazovoi Sredy, Uskorennii, Peregruzok i Drugikh Faktorov (ed. by V.V. Parin et al), 1968, pp. 34-36.

AUTHOR(S): Portugalov, V.V. and K.D. Rokhlenko

EXPERIMENT TITLE: Changes in Striated Muscle Fibers of Mice Under
Restrained Conditions

SUBJECTS: 10 Mice (Balb/C line)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 5 control; 2) 5 experimental mice kept for
15 days in small cages. Samples of the medial part of the quadriceps
muscle were examined by electron microscope.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: The myofibrillar apparatus, mitochondria and sarcoplasm of
muscle fibers developed changes, including: 1) thinning and splitting
of myofibrils; 2) increase of sarcoplasm containing glycogen granules;
and 3) accumulation of mitochondria in muscle fibers and swelling of
mitochondria (with transparent matrix and focal damage to crysts).

SOURCE: Space Biology and Medicine 3(1): 70-79, 1969

AUTHOR(S): Portugalov, V.V., E.I. Ilyina-Kakueva, V.I. Starostin,
K.D. Rokhlenko, and Z.F. Savik

EXPERIMENT TITLE: Morphological and Cytochemical Studies of Hypokinetic
Effects

SUBJECTS: 240 Mature white male rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control rats; 2) experimental rats were rigidly restrained in small cages. All animals were killed by ether inhalation after 1, 3, 5, 7, 15, 30, 45 and 60 days. For cytochemical studies identical muscles (quadriceps, gastrocnemius and soleus) were dissected from the hind limbs of experimental and control animals. Histological studies were also performed.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: The weight of restrained rats was much less than of the controls. Skeletal muscle changes were seen as early as the first day of exposure; by the 3rd day changes were noted in all structural components of muscle fibers. By the 15th day, the large number of disturbed fibers suggested the development of pathological processes rather than functional disorders. Histological and electron microscopical studies showed myofibril disorientation and disintegration. Diminished mobility induced shifts in the rate of different metabolic processes. Animals returned to a normal environment following 60-day test showed incomplete normalization of muscle structure and metabolism.

SOURCE: Aerospace Medicine 42(10): 1041-1049, 1971

AUTHOR(S): Portugalov, V.V., Y.I. Il'ina-Kakeyeva, V.I. Starostin,
K.D. Rokhlenko, and Z.F. Savik

EXPERIMENT TITLE: Structural and Cytochemical Changes in the Rat's
Skeletal Muscles Associated With Restricted Mobility

SUBJECTS: 240 Mongrel male rats

AREA OF STUDY: Muscular; Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control rats; 2) experimental rats were
placed in small cages and sacrificed 1, 3, 5, 7, 15, 30, 45 and 60 days
after the experiments. Cytological and histological studies were made
on muscles. Diet: standard pellet.

IMMOBILIZATION METHOD: Cage

RESULTS: Distinct edema in the soleus was observed after one day. On
the 3rd day, there were diverse forms of destruction of the contractile
elements. The 5th-7th day examination revealed great variability of
muscle fiber size as well as atrophy and disintegration. Atrophy of
soleus muscle fibers was observed only after the 30th day whereas signs
of hypertrophy were demonstrated before this time. Local disturbances in
the blood supply to muscles was observed.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 11: 82-91, 1971

AUTHOR(S): Portugalov, V.V., Ye.I. Il'ina-Kakuyeva, and V.I. Starostin

EXPERIMENT TITLE: Effect of Hypoxia on the Skeletal Muscles of Rats
During Hypokinesia

SUBJECTS: 48 Adult white male Wistar rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Four groups: 1) kept in small cages; 2) kept in small cages and daily kept in a pressure chamber at reduced barometric pressure of 405.09 mm Hg for 6 hr; 3) kept in ordinary cages and were also kept daily in a pressure chamber for 6 hr; 4) controls, kept in ordinary cages under vivarium conditions. The animals were killed after 14 and 30 days. Measurements: activity of α -glycerophosphate dehydrogenases (α -GPDH and α -GPDH), β -oxybutyrate (OBDH), glutamate (GDH), α -ketoglutarate (α -KGDH), succinate (SDH), glucose-6-phosphate (G-6-PHH), NADH₂ dehydrogenase, A and B phosphorylases, and lipids.

IMMOBILIZATION METHOD: Cage

RESULTS: Hypokinesia resulted in a change in the cytochemical indices of the muscle tissue and an impairment of its structure. To a high degree these changes were expressed in the soleus muscle, and to a lesser degree in the gastrocnemius muscle fibers. The direction of changes in the activity of a number of oxidative enzymes in muscle fibers of the soleus muscle and fibers of the first type in the gastrocnemius muscle was different. The attempt to use hypoxia as a factor preventing the development of the hypokinetic syndrome was a failure.

SOURCE: Space Biology and Medicine 6(3): 20-23, 1972

AUTHOR(S): Portugalov, V.V. and A.V. Gorbunova

EXPERIMENT TITLE: Hypokinetic Effects on the RNA and Protein Metabolism
in Motoneurons of Anterior Horns of the Rat Spinal
Cord

SUBJECTS: White male rats (180-200 gm)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental rats were placed in specially designed cages. On days 1, 3, 5, 7, 10, 14, 30, 45 and 60 of hypokinesia the spinal cord at the lumbar enlargement level of experimental and control animals was sampled simultaneously. Measurements: RNA content and concentration; protein content; nucleotide composition.

IMMOBILIZATION METHOD: Cage

RESULTS: A decline of the RNA content in motoneurons of the spinal cord anterior horns on the 1st, 3rd and 5th day of hypokinesia and its return to the pre-test level by the 7th day was found. A significant decrease of the RNA content was again detected on the 45th and 60th hypokinetic days. Microelectrophoretic determinations demonstrated that the nucleotide composition of RNA in spinal cord motoneurons remained unchanged throughout the entire experiment. Interferometrically the protein content was shown to decrease on the 3rd, 5th, 45th and 60th days of the experiment.

SOURCE: Acta Histochemica 45(1): 133-143, 1973

AUTHOR(S): Portugalov, V.V. and E.I. Ilyina-Kakueva

EXPERIMENT TITLE: Prolonged Space Flight and Hypokinesia

SUBJECTS: Rats

AREA OF STUDY: Muscular; Circulatory

OBJECTIVES: In title

PROTOCOL: Hypokinesia: 60 days. Electrical stimulation was done to determine if muscle changes during hypokinesia could be prevented.

IMMOBILIZATION METHOD: Not stated

RESULTS: Diminished motor activity produced morphological and cytochemical changes in skeletal muscles. Muscular activity decline was accompanied by growth stimulation and connective tissue differentiation. Sclerotic and perivascular sclerosis changes developed in the muscle stroma during prolonged hypokinesia. Electrical stimulation displayed no or very mild structural and metabolic changes in m. soleus.

SOURCE: Aerospace Medicine 44: 764-768, 1973

AUTHOR(S): Portugalov, V.V., Ye.I. Il'ina-Kakuyeva, and V.I. Starostin

EXPERIMENT TITLE: Use of Electric Stimulation for Preventing the
Development of Changes in Antigravitational
Muscles During Hypokinesia

SUBJECTS: 104 Male common rats (180-210 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Four groups: 1) controls; 2) restrained in tight individual cages; 3) same as group 2 but 5 times weekly the right rear paw was subjected to gradually increasing (5-7 min to 30 min by the end of the 1st wk; voltage, from 6-7 to 20 V) electrical stimulation; and 4) restrained, right rear paw was drawn from cage and fixed in position, but not electrically stimulated. Rats were killed on day 15 and 30 of the experiment. A morphological and cytochemical study was made of the gastrocnemius muscles of both extremities.

IMMOBILIZATION METHOD: Cage

RESULTS: Electrical stimulation had a favorable effect in 4 of 12 rats during every experimental run. Destructive changes and metabolic shifts in muscle fibers did not develop or appear in an insignificant degree.

SOURCE: Space Biology and Aerospace Medicine 9(1): 12-18, 1975

AUTHOR(S): Portugalov, V.V., K.D. Rokhlenko, and Z.F. Savik

EXPERIMENT TITLE: Changes in the Musculus Soleus (Red Muscle) During Decreased Functioning

SUBJECTS: 51 Male mongrel rats (180-200 gm)

AREA OF STUDY: Muscular; Circulatory

OBJECTIVES: In title

PROTOCOL: The rats were subjected to restricted mobility for 1, 3, 5, 7, 14, 30, 45 and 60 days. 6 or 7 animals were studied during each time period. The rats were placed in small cages but not completely immobilized. Muscle samples from the abdominal region were taken and examined microscopically.

IMMOBILIZATION METHOD: Cage

RESULTS: Decreased muscular activity was found to stimulate the growth and differentiation of connective tissue. It also appeared that muscle fiber innervation mechanisms were disrupted, in addition to the contractile and nutritive apparatus, and that the restructuring of vascular walls evidently also contributed to circulatory disorders.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 2: 11-18, 1975

AUTHOR(S): Portugalov, V.V., A.A. Ivanov, and V.N. Shvets

EXPERIMENT TITLE: Antitissue Antibodies and Complements During Hypokinesia

SUBJECTS: 39 Male common white rats (160 gm)

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats were placed in small cages. The animals were examined on days 7, 15, 30 and 60 of hypokinesia. For obtaining blood the animals were decapitated and immunological reactions were carried out with the blood serum. Measurements: complementary activity of serum; presence of antibodies of agglutinins to ram erythrocytes; level of complement-fixing antibodies to the muscle tissues.

IMMOBILIZATION METHOD: Cage

RESULTS: Long-term hypokinesia increased the complementary activity of the blood serum. Antibody levels to muscle tissue decreased during 7-15 days and increased during 30-60 days; this period showed increased isolation of agglutinin antibodies to ram erythrocytes.

SOURCE: Space Biology and Aerospace Medicine 10(2): 139-142, 1976

AUTHOR(S): Portugalov, V.V. and N.V. Petrova

EXPERIMENT TITLE: LDH Isoenzymes of Skeletal Muscles of Rats After Space Flight and Hypokinesia

SUBJECTS: Male rats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Four groups: 1) 22-day orbital flight, Cosmos-605 (14 rats); 2) ground-based simulation (15 rats); 3) hypokinesia - small cages (30 rats); 4) controls (50 rats). Rats from groups 1 and 2 were examined on the 2nd and 27th post-test days. The rats in group 3 were examined on days 7, 15, 35 and 60 of hypokinesia. Measurements: soleus and plantaris muscle metabolism; lactate dehydrogenase (LDH).

IMMOBILIZATION METHOD: Cage (small)

RESULTS: Red and mixed muscles reacted differently to flight and hypokinetic exposure. The greatest changes of the LDH spectrum in the soleus muscle were found on the 15th hypokinetic day, changes similar to those in flight rats. The most significant changes of the LDH spectrum in the plantaris muscle were seen on the 60th hypokinetic day, with no changes seen between flight and control rats.

SOURCE: Aviation, Space, and Environmental Medicine 47: 834-838, 1976

AUTHOR(S): Portugalov, V.V. and V.N. Shvets

EXPERIMENT TITLE: Proliferation and Differentiation of Hematopoietic Stem Cells During Hypokinesia

SUBJECTS: Female mice (20-22 gm)

AREA OF STUDY: Circulatory; Blood

OBJECTIVES: In title

PROTOCOL: The mice were kept in special small containers. On days 1, 3, 7, 15, 30 and 45 of hypokinesia the femoral bone marrow and spleen were removed from the mice. Cell suspensions were prepared from them and injected into the same mice after irradiation. On the 9th day after the transplantation of the cell suspension, the spleen and femora of the recipients were removed. Measurements: number of colonies; type of hematopoietic colonies (erythroid, myeloid, megakaryocytic, and mixed).

IMMOBILIZATION METHOD: Container (small)

RESULTS: Exogenous cloning of hematopoietic stem cells of bone marrow and spleen in the femur and spleen of recipient mice showed that during hypokinesia the kinetics of the stem cell population differed in the two organs. The character of differentiation of the transplantation stem cells from the different sources was undisturbed in the recipients' spleen. Bone marrow stem cells, settling in the femur, changed their character of differentiation toward an increase in erythropoietic function, whereas the direction of differentiation of the splenic stem cells was unchanged.

SOURCE: Bulletin of Experimental Biology and Medicine 81(4): 630-632, 1976

AUTHOR(S): Potapov, A.M.

EXPERIMENT TITLE: Some Indices of the Growth of Rats and Their Skeletal Muscles During Prolonged Restriction of Mobility

SUBJECTS: 80 Male Wistar rats (176.0±1.8 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats were placed in individual plastic chambers for 4 mo. The rats were killed by injecting them with an overdose of Nembutal. Measurements: body weight; muscle weight.

IMMOBILIZATION METHOD: Chamber (individual plastic)

RESULTS: Hypokinesia resulted in the delayed growth of the animals and their skeletal muscles. The inhibitory effect of hypokinesia on the development of the animals and their muscles was most distinct during the 2nd mo. The exposure produced a greater effect on the growth of flexors in the ankle joint than on the extensors.

SOURCE: Space Biology and Medicine 6(2): 23-30, 1972

AUTHOR(S): Potapov, P.P.

EXPERIMENT TITLE: Mucopolysaccharides and Collagen of Tissues in Hypokinetic Rats

SUBJECTS: 98 White rats (180-220 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 40 control rats; 2) 58 experimental rats were placed in individual small cages made of plexiglas to restrict mobility. Rats were decapitated on days 15, 30, 60 and 90 during the experiment and on days 15, 30 and 60 of the recovery period following 90 days of hypokinesia. Blood serum, tissues of the liver, heart, kidneys, brain and skeletal muscles from the posterior group of the thigh were studied. Measurements: hydroxyproline; hexosamine; hexuronic acid.

IMMOBILIZATION METHOD: Cage (small plexiglas)

RESULTS: Hydroxyproline, hexosamine and hexuronic acid levels in tissues of control animals remained constant throughout the experiment. There was an increased amount of collagen in the skeletal muscle, heart and kidneys of rats exposed to prolonged hypokinesia. The content of hexosamines decreased in the skeletal muscle, liver and brain and increased in the heart. The content of hexuronic acids increased in the skeletal muscle and kidneys and decreased in the heart. By the 60th day of the recovery period the collagen content in the skeletal muscle had not returned to normal. Changes in the content of mucopolysaccharides in the liver, heart, brain and skeletal muscle were in some cases more pronounced after than during exposure to hypokinesia.

SOURCE: Space Biology and Aerospace Medicine 11(3): 56-61, 1977

AUTHOR(S): Preobrazhenskaya, I.N.

EXPERIMENT TITLE: The Effect of General Hypokinesia on Blood Vessels of the Medulla Oblongata, Pons, and Midbrain of the Rabbit

SUBJECTS: 40 Rabbits (2500-3000 gm)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 4 controls; 2) 36 experimental rabbits were kept in close cages for 1-16 wk. Some experimental animals were then mobilized for 1-3 wk, others were killed immediately after the experiment. The circulatory system was injected with Paris blue mixed with chloroform through the ascending aorta. Following fixation in a 10% formalin solution, the brain was removed from the cranial cavity, and horizontal sections of the medulla oblongata, the pons, and the midbrain were prepared and studied under the microscope. The diameter of the blood vessels was measured and the average values of the total area of the vascular tree were calculated.

IMMOBILIZATION METHOD: Cage (close)

RESULTS: Individual blood vessels became sharply convoluted after 2-3 wk of hypokinesia. After 4 wk, sharply deformed arteries and veins were identified. Following 5-6 wk of hypokinesia blood vessels were deformed in places by spiral convolutions. Deformed arteries and convoluted vessels of the microcirculatory tree were found after 7-8 wk continuing and worsening up to 16 wk. 3-wk readaptation (staying in ordinary cages) did not lead to restoration of normal structure of the blood vessels. The vascular tree reached to hypokinesia with identical changes in all investigated regions of the brain.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 69(10): 33-39, 1975

AUTHOR(S): Prioux-Guyonneau, M.

EXPERIMENT TITLE: Repercussions of Restraint on Thermal Regulation in the White Rat Kept at Different Environmental Temperatures

SUBJECTS: 300 Female Wistar rats, 7-8 wk old (140-160 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Fourteen groups: 1) nonrestrained at $29 \pm 1^{\circ}\text{C}$; 2) restrained at $29 \pm 1^{\circ}\text{C}$; 3) nonrestrained at $26 \pm 1^{\circ}\text{C}$; 4) restrained at $26 \pm 1^{\circ}\text{C}$; 5) nonrestrained at $23 \pm 1^{\circ}\text{C}$; 6) restrained at $23 \pm 1^{\circ}\text{C}$; 7) nonrestrained at $19 \pm 1^{\circ}\text{C}$; 8) restrained at $19 \pm 1^{\circ}\text{C}$; 9) nonrestrained at $17 \pm 1^{\circ}\text{C}$; 10) restrained at $17 \pm 1^{\circ}\text{C}$; 11) nonrestrained at $14 \pm 1^{\circ}\text{C}$; 12) restrained at $14 \pm 1^{\circ}\text{C}$; 13) nonrestrained at $10 \pm .5^{\circ}\text{C}$; 14) restrained at $10 \pm .5^{\circ}\text{C}$. The animals were immobilized for periods varying from 50 min to $3\frac{1}{2}$ hr, then released and placed in groups of 4 in crystallizers at an ambient temperature of 23°C or 10°C . Measurements: rectal temperature.

IMMOBILIZATION METHOD: Metal mesh cylinder

RESULTS: A restraint of $2\frac{1}{2}$ hr at environmental temperatures less than thermal neutrality led to hypothermia whose degree is a function of the temperature of the environment. The rectal temperature dropped by 2.8, 3, 6, 9 and 19°C when rats were immobilized for $2\frac{1}{2}$ hr at 23, 19, 17, 14 and 10°C respectively. Hypothermia observed in rats restrained at 10°C was a function of the length of the restraint. Following cessation of restraint, the reversibility of the blockage of thermal regulation was a function of the degree of hypothermia and of the ambient temperature at which the released rats were kept. A considerable hypothermia was maintained for 5 hr and then reversed.

SOURCE: Comptes Rendus des Seances de la Societe de Biologie et de ses Filiales 164: 72-75, 1970

AUTHOR(S): Prioux-Guyonneau, M. and L. Buchel

EXPERIMENT TITLE: Metabolism of Lipids and Glucides in the White Rat
During Two Types of Stress: Forced Immobilization
and Heat Variations

SUBJECTS: Female Wistar rats (140-180 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Six groups: 1) free rats exposed to 10°C for 2 1/2 hr;
2) restrained 2 1/2 hr at 28°C; 3) restrained 2 1/2 hr at less than 19°C;
4) free rats kept at 10°C for 10 days; 5) restrained 2 1/2 hr at 10°C
after 10 days at 10°C; 6) controls maintained at 22°C. Measurements:
plasma free fatty acid content; blood glucose; rectal body temperature.

IMMOBILIZATION METHOD: Flexible metal gauze cylinder

RESULTS: In the unrestrained rat, cooling caused an increase in the
plasma-free fatty acid content and hyperglycemia. Restraint in animals
kept at normal temperatures caused a decrease in the plasma-free fatty
acid content and an increase in glycemia. A combination of the 2 stresses
did not change the plasma-free fatty acid content but provoked pronounced
hypoglycemia and hypothermia.

SOURCE: Comptes Rendus des Seances de la Societe de Biologie et de ses
Filiales 166: 1277-1283, 1972

AUTHOR(S): Prokhazka, I., I.V. Khavkina, and Z.I. Barbashova

EXPERIMENT TITLE: The Effect of Prolonged Hypokinesia on the Heart Muscle of Rats

SUBJECTS: Male Wistar rats (220-270 gm)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls, nonrestrained; 2) hypokinesia in a plexiglas cage for 30-40 days. Rats were decapitated, hearts exposed and examined. Measurements: myocardium performance capacity; resistance to hypoxic stress; anaerobic metabolism rate; body weight.

IMMOBILIZATION METHOD: Cage (plexiglas)

RESULTS: Hypokinesia for 30-40 days caused a decrease in both body weight (43% lower than controls) and heart weight, 20% lower than controls in the left and 36% in the right ventricles. Weakening of the contractility of the myocardium and its resistance to hypoxic stress were found. There was a small reduction in the anaerobic metabolism rate of the ventricles: of glycolysis and glycogenolysis in the right ventricle and glycogenolysis in the left ventricle. The glycogen content of the heart muscle remained unchanged.

SOURCE: Fiziologicheskii Zhurnal SSSR Imeni I M Sechenova 59(8): 1237-1241, 1973

AUTHOR(S): Prokhonchukov, A.A., Ye.A. Kovalenko, A.G. Kolesnik,
Yu.I. Kondrat'yev, and N.A. Ilyushko

EXPERIMENT TITLE: The Effect of Hypodynamia on Mineral and Protein
Metabolism in Calcified Tissues of the Maxillo dental
System

SUBJECTS: 60 Rats

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls, 20 rats; 2) hypokinetic in specially
constructed cages for periods of 15, 30, 60 and 100 days, 40 rats. Measure-
ments: mineral and protein metabolisms using radioisotope methods and
indices of P^{32} and Ca^{45} uptake in the mineral fraction and $2C^{14}$ -glycine and
 P^{32} uptake in the protein fraction of the teeth (molars and incisors) and
bones (maxillary and femoral).

IMMOBILIZATION METHOD: Cage

RESULTS: Combined alterations in mineral and protein metabolism occurred
in the calcified tissues of the experimental animals. The most pronounced
changes were found in P^{32} and $2C^{14}$ -glycine metabolism. In the incisors
and femoral bones, these alterations occurred in two phases: P^{32} and
 $2C^{14}$ -glycine uptake first increased, then decreased. Changes in Ca^{45}
metabolism were less pronounced, particularly in the initial period of
the experiment. A marked reduction in P^{32} , Ca^{45} , and $2C^{14}$ -glycine uptake
was found in various fractions of the calcified tissues on the 100th day
of experimental hypodynamia.

SOURCE: Stomatologiya 49(4): 1-6, 1970

AUTHOR(S): Prokhorov, V.Ya., V.M. Shilov, and E.A. Borman

EXPERIMENT TITLE: The Course of Experimental Staphylococcus Infection
in Albino Mice During Action of Certain Factors of
Space Flight

SUBJECTS: 200 Mongrel male white mice (18-20 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Four groups of 50 each: 1) controls; 2) subjected to acceleration overload up to 30 G for 15 min; 3) hypokinesia for 30 days; 4) hypokinesia for 30 days, then subjected to acceleration overload for 15 min. After acceleration, hypokinesia or both, an acute staphylococcus infection was induced by peritoneal administration of a lethal dose of virulent staphylococcus strain L-1726. At intervals of 15 min, 1 hr and 3 hr after infection, 3 mice from each group were decapitated. Their abdominal cavity was opened and a study of the peritoneal exudate and renal homogenate was made. Measurements: live staphylococci; phagocytic activity; content of alpha toxin.

IMMOBILIZATION METHOD: Not stated

RESULTS: Most adverse effect on the course and outcome of staphylococcus illness came from the combined effect of hypokinesia and acceleration. The animals showed pronounced depression of phagocytic activity and the formation of a considerable amount of alpha toxin, which caused their rapid demise.

SOURCE: Zhurnal Mikrobiologii, Epidemiologii i Immunobiologii 47(11):
82-86, 1970

AUTHOR(S): Pruss, G.M. and V.I. Kuznetsov

EXPERIMENT TITLE: Contractile Function of the Myocardium During Hypodynamia

SUBJECTS: Sexually mature white male rats (180-250 gm)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control rats; 2) experimental rats were kept in individual cages. Acute experiments for studying the parameters of the contractile function of the myocardium were carried out on the rats under urethane anesthesia with an opened chest cavity and artificial respiration on the 5th, 15th, 30th, 45th and 60th days of hypodynamia. The indices of the contractile function of the heart of the animals was determined before and after total compression of the mouth of the aorta. Diet: no restrictions. Measurements: body weight; frequency of cardiac contractions; intraventricular pressure; time of pressure increase.

IMMOBILIZATION METHOD: Cage (plastic)

RESULTS: Contractile function of the myocardium varied physically during hypodynamia. During the 1st 5 days the intensity and rate of the myocardial contractions diminished. By the 15th day the contractile function of the myocardium improved and on the 30th day of hypodynamia the basic parameters did not differ from those in the control rats. On the 45th and 60th days the parameters of the contractile function of the myocardium increased slightly. However, beginning with the 30th day of hypodynamia the functional reserve of the heart had decreased, which may lead to cardiac failure.

SOURCE: Space Biology and Aerospace Medicine 8(6): 74-81, 1974

AUTHOR(S): Pruss, G.M., V.I. Kuznetsov, and A.A. Zhilinskaya

EXPERIMENT TITLE: Catecholamines and Myocardial Contractile Function
During Hypodynamia and With an Altered Thyroid
Hormone Balance

SUBJECTS: 109 White male rats (170-250 gm)

AREA OF STUDY: Circulatory; Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control rats; 2) experimental. The experimental animals were placed in individual gripping cages made of organic glass. The contractile function of the heart and the content of catecholamines in the myocardium were studied for 5, 15 and 30-day hypodynamia. Thyroidin was administered through a probe in the stomach in a 1% amyloid paste in a dosage of 1.5 mg/100 gm animal weight. The administration of thyroidin was begun on the fifth day before the experiment and daily during the course of the test period of hypodynamia. A starchy paste was administered to the control rats. Diet: water and food ad libitum. Measurements: adrenalin and noradrenalin content; frequency of cardiac contractions; intraventricular pressure; time of relaxation.

IMMOBILIZATION METHOD: Cage (glass gripping)

RESULTS: The content of catecholamines and contractile function of the heart in conditions of rigorous hypodynamia changed according to phase. In the first 5 days the adrenalin content and noradrenalin content, and also, the strength and rate of contraction of myocardial tissue were lowered. The administration of thyroidin raised the content of catecholamines, increased the contractile function of the heart and its tolerance. On the 15th day of hypodynamia the content of noradrenalin in the heart approached the norm, the contractile function of the myocardium improved and the administration of thyroidin had but little effect. On the 30th day of hypodynamia the content of noradrenalin, strength and rate of contraction of the myocardium approached normal values, but the functional reserve of the heart decreased.

SOURCE: Izvestiia Akademii Nauk SSSR, Serii Biologicheskaya 2: 187-195, 1975

AUTHOR(S): Pudov, V.I. and V.A. Sosenkov

EXPERIMENT TITLE: Effect of Immobilization Stress on the Level of Macroergic Phosphates in the Blood of Rats

SUBJECTS: 79 Male rats (200-250 gm)

AREA OF STUDY: Blood; Endocrine

OBJECTIVES: In title

PROTOCOL: Immobilization: 1, 2, 24 hr or 2 hr daily for 7 days. The rats were immobilized by being tied to a bench. Measurements: adenylic nucleotides (ATP, ADP, AMP), inorganic phosphorus, lymphocytes and eosinophils in the blood; relative weight of the thymus and adrenals.

IMMOBILIZATION METHOD: Bench

RESULTS: There was a progressive reduction of ADP and ATP content in the blood during 24 hr of immobilization. This was accompanied by an increase in lymphocytes and eosinophils in the blood, a fall of the relative weight of the thymus and a gain in the weight of the adrenals. In the animals immobilized for 2 hr daily for 7 days the concentrations of ATP, ADP, and inorganic phosphorus on the 1st and 2nd day was below the normal level, and then showed a gradual increase, with complete normalization in 6-7 days, with the exception of inorganic phosphorus.

SOURCE: Patologicheskaya Fiziologiya i Eksperimentalnaya Terapiya
No.5: 73-75, 1975

AUTHOR(S): Puzanova, L. and J. Parizkova

EXPERIMENT TITLE: Changes in the Diameter of Muscle Fibers in Male Rats
Adapted to Exercise and Hypokinesia

SUBJECTS: White rats (90 or 150 days old)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: The group of full grown rats (150 days old) and the group of young rats (90 days old) were each divided into 3 subgroups: 1) controls; 2) rats exposed to daily treadmill exercises starting when 18 days old; 3) rats confined to restricted movement in small cages. Measurements: diameter of muscle fibers; body weight; body composition; relative weights of heart, musculus tibialis and musculus soleus.

IMMOBILIZATION METHOD: Cage (8 x 12 x 20 cm)

RESULTS: A rather indistinct hypertrophy of muscle fibers was detected in full grown experimental animals exposed to increased motor activity. The increase represented around 10% of the thickness of muscle fibers of the control animals. However, in young animals this increment was higher (15-20%). No pronounced changes were found in either full grown or young animals with restricted motor activity as regards the thickness of fibers compared to those of control muscles. Two of the studied full grown animals showed a decrease of 5%, i.e. a slight decrease in the diameter of muscle fiber; in young animals a certain decrease was measured only twice (5% in one animal, 10% in the other). Otherwise, the values were analogous to the control animals.

SOURCE: Sbornik Lekarsky 78(4): 85-90, 1976

AUTHOR(S): Pyke, R.E., P.B. Mack, R.A. Hoffman, W.W. Gilchrist,
W.N. Hood, and G.P. George

EXPERIMENT TITLE: Physiologic and Metabolic Changes in Macaca nemestrina
on Two Types of Diets During Restraint and Non-restraint:
III. Excretion of Calcium and Phosphorus

SUBJECTS: Macaca nemestrina (7.4-8.4 kg) monkeys

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Four groups: 1) control, non-restrained and Diet A; 2) restrained and Diet A; 3) non-restrained and Diet B; 4) restrained and Diet B. The 'restrained' primates were strapped in couches (a hammock of nylon net strung in a rectangular aluminum frame) for 35 days with a subsequent exposure to a Biosatellite simulated reentry profile with centrifugation to 12-G followed by a 35-day period of post-restraint on the same diet. The non-restrained groups remained in metabolism cages except on the 35th day when they also were exposed to the reentry profile. Diet B was superior in all nutrients (except protein) for which analyses were made; Diet B had three times as much calcium and almost one and one-half times as much phosphorus as Diet A. The two diets were similar in provision of energy. Measurements: calcium and phosphorus in daily samples of urine and feces.

IMMOBILIZATION METHOD: Couch

RESULTS: Restraint per se elevated the calcium fecal/urinary quotient. The groups undergoing restraint and Diet B (higher calcium/phosphorus diet) excreted more calcium than did the nonrestraint group on Diet B. Restraint combined with Diet A resulted in elevations of urinary and fecal phosphorus, whereas Diet B caused a reduction in urinary phosphorus of large magnitude, with a concurrent elevation in fecal phosphorus. When restraint and Diet B acted together, an unusual rise in urinary phosphorus occurred with a slight increase in fecal phosphorus; it experienced another increase during the recovery period when only the diet was operative.

SOURCE: Aerospace Medicine 39: 704-708, 1968

AUTHOR(S): Radulovacki, M.

EXPERIMENT TITLE: Comparison of Effects of Paradoxical Sleep Deprivation and Immobilization Stress on 5-Hydroxyindoleacetic Acid in Cerebrospinal Fluid

SUBJECTS: 11 Cats (3-7.5 kg)

AREA OF STUDY: Nervous; Behavior

OBJECTIVES: In title

PROTOCOL: All cats were implanted with a cannula in the cisterna magna. 2 groups: 1) for 6 days and nights, 6 cats were deprived of paradoxical sleep (DPS) by placement on a pedestal too small to relax on without falling into the water surrounding the pedestal; after a 7-day interval, 2 of the cats were subjected to repeated DPS (RDPS) for 5 days; 2) 5 cats were immobilized by placement on pedestals large enough to relax on without falling into the surrounding water for 4 days and nights; cats had access to food once a day for 30 min. Measurements: cisternal 5-hydroxyindoleacetic acid (5-HIAA); cerebral spinal fluid (CSF); body weight.

IMMOBILIZATION METHOD: Pedestal

RESULTS: Immobilized cats lost 7-110 gm weight vs 160-240 gm for DPS cats, and 120-170 gm for RDPS cats. Immobilization increased 5-HIAA in the CSF with a significant increase seen by day 3. Immobilization alone and the loss of PS affected 5-HIAA.

SOURCE: Brain Research 60: 255-258, 1973

AUTHOR(S): Rakova, I.A. and V.N. Shvets

EXPERIMENT TITLE: Morphological Study of Hemopoietic Organs of Hypokinetic Rats

SUBJECTS: Male rats(200-250 gm)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental rats were immobilized in individual box-cages for 7-60 days. After 7, 15, 30 or 60 days the animals were decapitated. Measurements: femoral and tibial bone marrow, spleen and thymus histology. Peripheral blood analysis.

IMMOBILIZATION METHOD: Cage (individual box-cage)

RESULTS: There was an increase in erythropoietic activity of bone marrow at the early stage of hypokinesia and reduction at the later stage; a decrease in lymphopoiesis and myelopoiesis and injury to megakaryocytes by the end of the experiment.

SOURCE: Space Biology and Medicine 12(4); 85-90, 1978

AUTHOR(S): Rassolova, N.P., A.N. Potapov, I.M. Sapelkina, and
I.I. Grebennikova

EXPERIMENT TITLE: Effect of Prolonged Hypokinesia on Some Indices of
Energy Metabolism in the Skeletal Muscles and in
Some Internal Organs

SUBJECTS: 30 Male common rats (200 gm)

AREA OF STUDY: Muscular; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental rats placed in specially
designed cages for 120 days. Energy metabolism in 5 striated muscles -
tibialis anterior, long extensor of the toes, gastrocnemius, soleus, and
plantar - and in the myocardium and liver was studied. Diet: concentrated
feed; water ad libitum. Measurements: oxidation; phosphorylation; enzymes.

IMMOBILIZATION METHOD: Cage

RESULTS: Continuing exposure resulted in decreased oxidative phosphorylation
and increased anaerobic oxidation. This was seen clearly in the skeletal
muscles and less distinctly in the myocardium and liver. Muscles showed
morphological signs of atrophy.

SOURCE: Space Biology and Medicine 7(2): 37-46, 1973

AUTHOR(S): Razin, S.N. and A.V. Rychko

EXPERIMENT TITLE: State of the Body in Disorders of Diurnal Physiological Rhythms and Long-Term Hypokinesia

SUBJECTS: 50 Male Wistar rats

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: The experimental animals were placed in cages for 7-19 hr daily for 30, 60 or 90 days. Fifty animals were studied: 8 in a background group and 7 animals each in experimental and control groups for each period of hypokinesia. At the end of the experiment the rats were decapitated, body weight determined, and the brain, hypophysis, and adrenals removed, fixed and slides prepared.

IMMOBILIZATION METHOD: Cage

RESULTS: The body's growth and development were arrested when physiological rhythms were grossly disturbed by artificial hypokinesia. The weight deficit of the experimental animals relative to the controls amounted to 28.1, 30.6 and 20% after 30, 60 and 90 days of hypokinesia, respectively. Change in the adrenals was manifested by a sharp increase in the relative weight of the glands during the first period of motion restriction and decrease in these indices in the subsequent one. They did, however, remain at a higher level relative to the control group of animals. Morphological changes in the adrenals after 30 days of the experiment were manifested by pronounced hypertrophy of the fascicular layer, and a large quantity of alveolar, vacuolized, and clear cells with spherical and pyknotic nuclei in them. In the subsequent period of the experiment (60 and 90 days), atrophy of the adrenal cortices developed.

SOURCE: Vrachebnoe Delo No 5: 104-106, 1976

AUTHOR(S): Redgate, E.S. and B.E. Eleftheriou

EXPERIMENT TITLE: The Effect of Recaging into Groups or into Isolation on the Pituitary Adrenal Response to Immobilization of Different Age Groups of C57BL/6J Mice

SUBJECTS: 120 Male C57BL/6J mice (49 ± 3 , 255 ± 10 and 720 ± 30 days old)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Four groups: 1) controls, 8 mice of each age group (49 ± 3 , 255 ± 10 and 720 ± 30 days old), housing unaltered; 2) 8 mice of each age group were transferred to cages of 4 mice each without altering the grouping; 3) and 4) cages of 4 mice each of the 3 age groups were transferred to cages of 2 or 1 each. All mice were immobilized for 15 min in a plastic cylinder, 30 mm diameter by 45 mm depth, after 24 hr of regrouping. Blood samples were obtained by tail vein puncture before and after the immobilization or 60 min after treatment with ACTH (20 milliunits im). Diet: Purina lab chow 1193. Measurements: serum corticosterone levels by radio-immunoassay.

IMMOBILIZATION METHOD: Plastic cylinder (30 x 45 mm)

RESULTS: Preimmobilization levels of corticosterone and increments in corticosterone in response to ACTH treatment were smaller in 255 day old mice than in 49 or 720 day old mice; preimmobilization corticosterone levels of control and recaged 49 and 255 day old mice were similar. In 49 day old mice, recaging increased the immobilization-evoked increment in corticosterone, but in 255 and 720 day old mice, recaging in groups or pairs did not change the response. Recaging of 720 day old mice in isolation resulted in a decrease in the immobilization-evoked increment.

SOURCE: Life Sciences 23: 2467-2474, 1978

AUTHOR(S): Refior, H.J. and G. Huebner

EXPERIMENT TITLE: On the Morphology of Hyaline Cartilage in Case of Immobilization and Remobilization

SUBJECTS: 18 Young mature rabbits

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: The right hind legs of 18 rabbits were immobilized at an acute angle for 2-4 wk by means of an external splint. In 8 of the animals, the external fixating device was removed and the joint was remobilized for $\frac{1}{2}$ yr. After the individual testing periods, the animals were killed. The left untreated knees of these rabbits and the knee joints of animals of the same age which had not been subject to the test conditions were used as controls. Measurements: macroscopic, histological and electron microscopic evaluation of the hyaline joint cartilage.

IMMOBILIZATION METHOD: External splint

RESULTS: Granular abrasion in the cartilage, rupture, fragmentation, and fine lamellary swellings of the fibrillary structure were observed after 4 wk. The typical net-pattern of the surface of the joint cartilage could not be observed. There was cellular shrinkage, reduced coloration of the amorphous basic substance, and rupturing of the tangential fiber layer of the tangential and transition zones of the cartilage. In the chondrocytes, there was an increase in ergastoplasm and fat deposits in the cells. Animals whose knee joints were remobilized for $\frac{1}{2}$ yr after the immobilization period showed that the damage did not reverse and heal.

SOURCE: Archives of Orthopaedic and Traumatic Surgery 91: 305-314, 1978

AUTHOR(S): Reid, G.

EXPERIMENT TITLE: A Comparison of the Effects of Disuse and Denervation
Upon Skeletal Muscle

SUBJECTS: 6 Cats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Denervation: right limb; disuse: left limb. Denervation process: lumbar laminectomy was performed on 6 cats; the spinal cord was divided by silk ligatures above the 4th lumbar and below the 2nd sacral segments. The dorsal roots of the intervening segments were divided intradurally on each side; the ventral roots were divided extradurally on the right side. Both hind limbs were encased in plaster of Paris casts. Three cats survived for 5, 6 and 10 wk respectively. Measurements: strength-duration (through electrical stimulation) and weight of gastrocnemii muscles.

IMMOBILIZATION METHOD: Plaster of Paris cast and denervation

RESULTS: Muscular atrophy was more pronounced on the denervated than on the disused side. The animals killed at 5 and 6 wk were shown to have an intact motor innervation of the left gastrocnemius (disused side). Each of the animals showed alteration in the shape of the strength-duration curve of the right gastrocnemius muscle (denervated). The curve of the left gastrocnemius resembled that of a normal muscle. Fibrillation was present on the right but not on the left. Nuclei retained their normal shape, staining, and situation in the disused side, unlike the denervated side.

SOURCE: Medical Journal of Australia 2: 165-167, 1941

AUTHOR(S): Reklewska, B., L. Tomaszewska, H. Kaciuba-Uscilko, and S. Kozlowski

EXPERIMENT TITLE: Changes in the Thyroid and Adrenal Glands During Prolonged Immobilization of Rats

SUBJECTS: 48 Albino rats (203-255 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental rats placed in special plastic cages. All the animals were given food and water ad libitum. On the 10th, 21st, 42nd and 56th days, 6 rats from each group were weighed and injected ip with $1\mu\text{Ci}$ of ^{131}I . 3 hr after the injection, the rats were killed by decapitation. Both lobes of their thyroids were removed, weighed, and the total radioactivity was measured by means of a scintillation probe connected with an LL-1 counter. Immediately after the measurements, the left lobe of the thyroid was fixed in Bouin's fluid for histological examination. The $7\text{-}\mu$ -thick histological slices were stained either with hematoxylin and eosin or using the periodic-acid-Schiff method. The uptake of ^{131}I by the thyroid gland was expressed as a percentage of the injected dose and then calculated per 1 mg of the thyroid tissue. Both adrenals of the rats from the control and the experimental groups were removed immediately after decapitation of the animals, weighed, and fixed in 10% formaline solution. The $7\text{-}\mu$ -thick histological sections were stained with HE.

IMMOBILIZATION METHOD: Cage (plastic)

RESULTS: The microscopic structure of the adrenal glands of the immobilized rats changed markedly in comparison with the control animals. The uptake of ^{131}I by the thyroid glands of the immobilized rats was lower than that in the controls. Statistically significant differences between the two groups were noted on the 21st, 42nd and 56th days of the experimental period. The uptake of ^{131}I by 1 mg of thyroid tissue of the immobilized animals was also lower than that in the controls. Histological observations of the thyroids of the rats immobilized for 10 or 21 days did not show any distinct changes in morphological structure in comparison with the control animals. In some rats immobilized for longer periods (42 or 56 days), large follicles, low epithelial cells, and deeply stained, unvacuolized colloid were noted.

SOURCE: Bulletin de L'Academie Polonaise des Sciences 20: 685-689, 1972

AUTHOR(S): Repcekova, D. and L. Mikulaj

EXPERIMENT TITLE: Plasma Testosterone of Rats Subjected to Immobilization Stress and/or HCG Administration

SUBJECTS: Male Wistar rats (250 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: The animals were kept at 24°C under a 12-hr light-dark cycle. Immobilization was performed by taping the limbs to specially prepared metal mounts attached to a board for a duration of 10, 20, 60 and 120 min. After daily immobilization of the same duration for 3 consecutive days or for 42 days, the animals were killed by decapitation. In several experiments, 10 or 50 IU HCG was applied im for 3 consecutive days, and these animals were decapitated 2 hr after the 3rd injection. In a final experiment, immobilization and HCG administration (10 or 50 IU) for 3 days was combined. Blood was collected. Measurements: plasma testosterone.

IMMOBILIZATION METHOD: Metal mount, tape, and board

RESULTS: Plasma testosterone was not changed after 10 or 20 min of immobilization for 3 consecutive days and the 10-min trial was without effect even if it was applied daily for 42 days. 3 days of immobilization for 60 min caused a significant hormone decrease, which was even more pronounced after 3 or 42 days of immobilization for 120 min. The administration of HCG to rats immobilized 3 days for 120 min resulted in the increase of testosterone.

SOURCE: Hormone Research 8(1): 51-57, 1977

AUTHOR(S): Resnick, J.S., W.K. Engel, and P.G. Nelson

EXPERIMENT TITLE: Changes in the Z Disk of Skeletal Muscle Induced by Tenotomy

SUBJECTS: Cats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two series: 1) cat gastrocnemius and soleus muscles were tenotomized; 2) same procedure, studied 8-10 wk after operation. Measurements: electron microscopy.

IMMOBILIZATION METHOD: Tenotomy

RESULTS: Rod-shaped particles up to 1.2μ long, with regular dense striations at intervals of 150 to 170 Å oriented perpendicular to the long axis of the myofilaments were produced. The rods were of Z-disk density and appear to originate at the Z disk.

SOURCE: Neurology 18: 737-740, 1968

AUTHOR(S): Reushkina, G.D.

EXPERIMENT TITLE: Changes in Indices of State of the Parasympathetic Nervous System in Rabbits During Hypokinesia

SUBJECTS: 60 Male chinchilla rabbits (2.5-3 kg)

AREA OF STUDY: Nervous; Blood

OBJECTIVES: In title

PROTOCOL: Five groups: 1) 20 controls; 2) 10 rabbits restrained for 12 days; 3) 10 rabbits restrained for 30 days; 4) 10 rabbits restrained for 12 days and administered 0.5% strophanthin-K iv twice; 5) 10 rabbits restrained for 30 days and administered 0.5% strophanthin-K iv twice. Rabbits were restrained in cages. Measurements: acetyl choline content; cholinesterase.

IMMOBILIZATION METHOD: Cage

RESULTS: At the end of 30 days hypokinesia, rabbits lost an average of 500 gm weight. In controls, cholinesterase activity and acetyl choline content in blood were stable. Under 12-day restraint, acetyl choline content increased ($p < .025$), cholinesterase decreased ($p < .001$), and the ratio of acetyl choline and blood cholinesterase increased. There was a further increase in blood acetyl choline ($p < .01$) at the end of 30 days restraint; cholinesterase activity ($p < .025$) increased, and the ratio decreased. Strophanthin-K had a normalizing effect under both 12- and 30-day restraint.

SOURCE: Space Biology and Aerospace Medicine 10(2): 143-148, 1976

AUTHOR(S): Revich, G.G., N.P. Rassolova, and V.A. Zakharchenko

EXPERIMENT TITLE: Changes in the Content of Free Amino Acids in the
Organs and Tissues of Rats Under Hypokinetic Conditions

SUBJECTS: Male white rats (220 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Variations in the content of free amino acids in the gastrocnemius muscle, myocardium, and plasma were measured in rats kept for 35 to 60 days in cages. Measurements were also taken 30 days after the relief of the animals from the experimental conditions.

IMMOBILIZATION METHOD: Cage (adjustable)

RESULTS: 35 days of hypokinesia led to an increase in almost all amino acids in the gastrocnemius muscle and 60 days of hypokinesia resulted in a decrease. Similar changes were observed in the myocardium. Variations in the content of free amino acids in the plasma were identified in every experimental stage. Changes in protein metabolism persisted long after exposure of the animals to hypokinesia.

SOURCE: Space Biology and Aerospace Medicine 9(4): 45-54, 1975

AUTHOR(S): Rifkenberick, D.H. and S.R. Max

EXPERIMENT TITLE: Substrate Utilization by Disused Rat Skeletal Muscles

SUBJECTS: Adult male Wistar rats (250-275 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Disuse atrophy of soleus and plantaris muscle was produced by skeletal fixation. A 25-gauge needle was driven through the calcaneus into the shaft of the distal tibia, and a 21-gauge needle was driven through the distal femur into the proximal tibia. The contralateral soleus and plantaris muscles served as the controls. After 10 days following skeletal fixation, rats were killed, soleus and plantaris muscles were removed, weighed, and homogenized. The capacity of homogenates of muscle to oxidize various substrates was determined by measuring the rate of $^{14}\text{CO}_2$ production at 37°C .

IMMOBILIZATION METHOD: Internal fixation with needles

RESULTS: The rate of $^{14}\text{CO}_2$ production from palmitate-1- ^{14}C , β -hydroxybutyrate-3- ^{14}C , pyruvate-2- ^{14}C , glucose-U- ^{14}C , glucose-1- ^{14}C , and glucose-6- ^{14}C was markedly diminished (19-55% of control) in both soleus and plantaris muscles.

SOURCE: American Journal of Physiology 226: 295-297, 1974

AUTHOR(S): Riley, R.F., B. McCleary, and R.E. Johnson

EXPERIMENT TITLE: Denervation Atrophy of Bone and Muscle. An Examination of the Effect of Choline and Some Further Observations on the Metabolism of Phosphorylcholine and Deposition of P^{32} in Bone

SUBJECTS: 41 Male albino rats (140-200 gm)

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Four groups: 1) nerve sectioned; 2) nerve sectioned and daily injections for 21 days of 10 mgm choline chloride in isotonic saline; 3) sham operated controls; 4) sham operated controls and daily injections for 21 days of 10 mgm choline chloride in isotonic saline. In groups 1 and 2, the nerves of the brachial plexus were sectioned unilaterally at the axillary level. A portion of the nerve fiber was removed to insure against regeneration. Groups 3 and 4 were incised but the nerves not sectioned. An equal number of operations were made on right and left legs. The anterior portion of the animals was x-rayed on the 22nd day 24 hr prior to sacrifice, half of each group were given a trace dose of radioactive phosphorylcholine; the remaining rats received radioactive inorganic phosphate. The animals were sacrificed on the 24th day by decapitation; blood was taken, and humeri and flexor muscles were removed. Diet: Purina fox chow. Measurements: body weight; flexor muscle weight; humerus weight; radioactivity.

IMMOBILIZATION METHOD: Denervation

RESULTS: Daily administration of choline chloride had no significant effect on denervation atrophy of the humerus or the flexor muscles of the forelimbs in the rat. In rats weighing 150-250 gm, flexor muscles of the forelimb weighed 56 to 59% less than controls 24 days after denervation. However, no net loss of muscle mass occurred in the denervation limb after the operation. Following unilateral brachial section, the humerus continued to gain in mass but at a slower rate. The 24 hr uptake of radioactive phosphorus by bone ash was the same in normal and atrophic limbs. The phosphorus of trace doses of calcium phosphorylcholine chloride did not enter bone ash preferentially to inorganic phosphate.

SOURCE: American Journal of Physiology 143: 677-686, 1945.

AUTHOR(S): Riskevich, G.G.

EXPERIMENT TITLE: Effect of G-Loads and Hypokinesia on the Structure of the Gastric Vascular Bed

SUBJECTS: 130 Male rabbits (2.3-2.5 kg)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Six groups: 1) subjected to 1 maximum endurable G-load (9.6 G) in either caudad, cephalad or ventro-dorsal direction; 2) confined to cramped cages for 1, 2, 4, 8 or 12 wk; 3) sequential effect of G-loads and hypokinesia for 4 and 12 wk; 4) subjected to single application of maximum endurable G-load in 1 direction, 4 wk hypokinesia then hyper-gravitation in the same direction; 5) subjected to same as group 4 but pretrained for gravitational stress; 6) controls. Measurements: histology and roentgenography of blood vessels of the stomach.

IMMOBILIZATION METHOD: Cage (cramped)

RESULTS: Maximum endurable stress of the ventro-dorsal direction caused fewer morphological changes than stresses of longitudinal directions. With 1-12 wk hypokinesia, changes became more pronounced in all layers of the stomach. The combination of gravitational stress and hypokinesia for 4-12 wk caused greater changes than isolated conditions. Animals subjected to gravitational stress before and after 4 wk hypokinesia developed vascular changes typical for gravitational effects. Pre-training showed no positive effect.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 68(5): 118-124, 1975

AUTHOR(S): Ritter, B.

EXPERIMENT TITLE: Effect of Chronic Restraint on Open Field Activity of Aging C57BL/6N Mice

SUBJECTS: 58 Male C57BL/6N mice, 8 to 31 mo old

AREA OF STUDY: Behavior

OBJECTIVES: In title

PROTOCOL: Three age groups: 1) 8 mo old; 2) 20 mo old; 3) 31 mo old. One-half the mice in each age group were assigned to the physical restraint treatment. The other half served as controls. Restrained mice were placed in wire mesh envelopes for 24 hr periods on the 1st, 3rd and 5th day of each week beginning 5 wk before the 1st open field test. The 2nd test series was done in the 6th wk. All mice were tested in an open field apparatus divided into 25 12.7 cm squares for 5 consecutive 2 min trials. Restrained mice were tested on alternating restraint and nonrestraint days. A corresponding alternation of test days was used with nonrestraint control mice. Measurements: number of squares entered with all 4 feet.

IMMOBILIZATION METHOD: Wire mesh envelope (5.1 x 7.6 cm)

RESULTS: Alternation of test days had no effect. There was an increase in activity between the 1st and 10th trials among both nonrestrained and restrained 31 mo old mice, and an activity increase between the 1st and 2nd trials among nonrestrained mice. Restrained mice were more active than nonrestrained mice on the 1st trial of series 1 and on all trials in the 2nd series of tests. Restrained mice, but not nonrestrained subjects, made a significant recovery in activity between the last trial on series 1 and the 1st trial of series 2. 20 and 31 mo old restraint subjects showed a large mean increase in activity from series 1 to series 2, whereas the 8 mo old restraint mice did not change. For nonrestrained mice, the trend was the opposite. 8 mo old mice had a mean decrease in activity from series 1 to series 2, and the 20 and 31 mo old mice showed no significant change.

SOURCE: Experimental Aging Research 4(2): 87-95, 1978

AUTHOR(S): Robert, A., J.P. Phillips, and J.E. Nezamis

EXPERIMENT TITLE: Production, By Restraint, of Gastric Ulcers and of Hydrothorax in the Rat

SUBJECTS: Sprague-Dawley rats (198-215 gm)

AREA OF STUDY: Digestive; Circulatory

OBJECTIVES: In title

PROTOCOL: Eleven groups: 1) restrained in pliable window screen wrapped around the body and limbs and fastened with staples for 8 hr, fasted previously for varying intervals up to 2 days; 2) restrained for 24 hr, fasted previously for varying intervals up to 2 days; 3) restrained for periods ranging from 4-60 hr, not fasted prior to restraint; 4) restrained for 24 hr, released but deprived of food and water for up to 24 hr afterwards; 5) restrained for 24 hr, rats spaced 15 cm apart or with screens touching each other during restraint; 6) restrained for 24 hr at 24°C or 28°C; 7) adrenalectomy performed 6 days prior to restraint for 24 hr, with and without administration of either deoxycorticosterone or prednisolone; 8) non-adrenalectomized, administered daily for 6 days prior to restraint either deoxycorticosterone or prednisolone; 9) restrained, saline solution infused during 24 hr restraint, fasted or non-fasted previously for 24 hr; 10) restrained for 24 hr, male and female groups; 11) restrained for 24 hr sc administration of methscopolamine bromide (1-5 mg/kg). All animals were immediately killed, thorax fluid removed, stomachs excised and examined. Diet: Purina laboratory chow and water ad libitum. Measurements: degree of hydrothorax, number and degree of ulcers.

IMMOBILIZATION METHOD: Pliable window screen fastened with staples

RESULTS: Previous fasting reduced ulcers and accumulation of pleural fluid (hydrothorax). The longer the fast, the greater the reduction. Hydrothorax was maximal after 24 hr restraint; ulcers increased until 60 hr restraint at end of experiment. Recovery time after restraint reduced ulcers by 1/2 after 24 hr, and completely rehabilitated hydrothorax. No hydrothorax was formed and the ulcer index was reduced by 34% in animals that were restrained next to each other, as opposed to those separated by 15 cm. The hematocrit index was elevated in those animals suffering from hydrothorax. Hyperthermia caused a reduction of 1/2 of the ulcer index and prevented hydrothorax. Adrenalectomy prevented only hydrothorax. Deoxycorticosterone administration had no effect while prednisolone inhibited hydrothorax in intact animals. Saline solution had no effect on hydrothorax under any condition. Females were more sensitive to ulceration and hydrothorax than males. Methscopolamine bromide prevented the development of ulcers but not hydrothorax.

SOURCE: Gastroenterology 51(1): 75-81, 1966

AUTHOR(S): Rohles, F.H., H.H. Reynolds, M.E. Grunzke, and D.N. Farrer

EXPERIMENT TITLE: Fourteen Day Restraint for an Orbital Flight with a Chimpanzee

SUBJECTS: Male chimpanzee, 63 mo old

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: Development of laboratory model for 14 day orbital flight

PROTOCOL: The chimpanzee had previously received 173 hr of training on performance tasks during 1 hr restraint period. He was placed in a body fitting plastic couch, wearing a nylon mesh suit with straps which attached to the couch and soft leather shoes with brass soles for delivering electrical shock. The performance test panel was attached to the couch and mounted in front of the chimpanzee. An isolation chamber contained this apparatus and provided controlled sound and constant illumination. For approximately 9 hr daily for 14 days he executed a complex performance schedule. On 2 programs, he was rewarded with food pellets and water, no ad libitum food or water was given. Measurements: skin temperature; pulse; respiration; feces and urine output; weight; pretest, immediate and 7 day posttest values for blood chemistry, urine, hematology; daily performance on continuous avoidance task, discrete avoidance task, differential reinforcement of low rate, fixed ratio task and oddity problem.

IMMOBILIZATION METHOD: Couch

RESULTS: The chimpanzee survived 14 days of social isolation and restraint without serious physical damage or behavior impairment. The performance schedule provided enough food and water to maintain weight. Improvement in the performance of the behavioral tasks occurred. The chimpanzee was weak when removed from the couch, but his recovery was rapid. Standards were given for food and water consumption, waste production, skin temperature, pulse and respiration.

SOURCE: Proceedings of a Conference on Research with Primates (ed. by D.E. Pickering), Tektronix Foundation, Beaverton, Oregon, 1963, pp. 27-48

AUTHOR(S): Rokhlin, G.D. and E.P. Levites

EXPERIMENT TITLE: Effect of Hypokinesia on the Development of Osteoporosis

SUBJECTS: Rabbits

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rabbits were placed in small cages for 3 mo. Roentgenodensitometry and roentgenogrammetry were done for all rabbits pre- and postexperiment. Diet: ordinary. Measurements: thickness of the cortical layer of the diaphysis of the hip bone; intensity of the roentgen image of the bone tissue.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: The cortical layer of the hip bone decreased by 0.27 mm, and the optical density decreased an average of 14%. Osteoporosis had a generalized nature: bone density decrease was noted in selectively investigated skeletal bones (pelvic bones and vertebrae of the cervical and thoracic parts of the backbone).

SOURCE: Space Biology and Aerospace Medicine 9(1): 30-34, 1975

AUTHOR(S): Rokotova, N.A., I.D. Bogina, O.P. Bolotina, T.M. Kucherenko, Ye.S. Rogovenko, and R.L. Shevkin

EXPERIMENT TITLE: The Effect of Prolonged Limitation of Motor Activity on the Activity of Monkeys

SUBJECTS: 4 Monkeys (2 macaque, 1 hamadryad, 1 capuchin)

AREA OF STUDY: Behavior

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 3 monkeys restrained for 10 days; 2) 2 monkeys restrained for 3.5 mo. The restraining device was a metal construction consisting of a base and oblong cleats to which 4 posts are attached. The animal was held by a belt, collar and a seat and, in the case of the capuchin monkey, with foot rests. The belt and collar were connected to the posts by means of compound rods with variable stiffness. The fixator had detachable Plexiglas side walls for containing the aggressive actions of the animal. During the experiments, the animal's behavior was monitored. Measurements: waking, sleep, motor and food reaction; body weight; respiration; pulse.

IMMOBILIZATION METHOD: Fixation apparatus

RESULTS: There were no changes in physiological function or activity under 10-day restraint. Prolonged restraint did not produce any marked changes during the first 20-30 days; food intake was slightly reduced during the later period of restraint. 1 monkey lost 41% of its body weight and another lost 19% in 41 days. Muscle rigidity and definite weakness of the hind limbs were seen after restraint; the symptoms lasted only for a day or so and then disappeared. After 3.5 mo, several days were required for the monkeys to regain normal activity. Orientation was more pronounced after restraint.

SOURCE: Problems of Space Biology 2: 424-434, 1962

AUTHOR(S): Romanov, V.S.

EXPERIMENT TITLE: Quantitative Evaluation of Ultrastructural Changes in the Rat Myocardium During Prolonged Hypokinesia

SUBJECTS: Male rats

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Immobilization: up to 120 days in cages. Rats were killed by decapitation on the 14th, 30th, 45th, 60th and 120th days from the onset of immobilization. The ultrastructural shifts in myocardial ventricular cells were examined. Measurements: redistribution of chromatin in nuclei; number and size of mitochondria; the ratio of the total area of the mitochondria to the total area of the myofibrils.

IMMOBILIZATION METHOD: Cage (confining)

RESULTS: The fraction of the area of diffuse chromatin increased to the 30th day, then to the 120th day it decreased, remaining above the control level. In both the left and right ventricles the redistribution of chromatin in the cell nuclei proceeded unidirectionally and at all times at an identical quantitative level. Quantitative restructurings in the mitochondrial apparatus were of different patterns: 14th day - number of mitochondria increased and size decreased; 30th day - size increased, number decreased; 45th and 60th days - relative normalization of number and size; 120th day - number and size increased, but remained below the level of 14 day hypokinesia. The ratio of the total area of the mitochondria to the total area of myofibers varied periodically; by the end of the experiment the mitochondrial area had increased. Quantitative changes in the organelles of the left ventricle of the myocardium were more significant than those of the right ventricle during the exposure.

SOURCE: Space Biology and Aerospace Medicine 10(4): 74-82, 1976

AUTHOR(S): Romanov, Yu.A., Ye.A. Kovalenko, S.S. Filippovich, E.T. Ostroushko, L.O. Stepanova, and E.A. Kamenetskaya

EXPERIMENT TITLE: Time-Related Organization of the Cell-Reproducing System of Some Tissues in Hypokinetic Rats

SUBJECTS: 40 Male mongrel rats (170 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control rats; 2) experimental rats were kept in special clamp-equipped small cages for 34 days. One hour before sacrifice, the animals were given a single dose of 0.5 μ Ci/gm body weight 3 H-thymidine ip. Measurements: mitotic and radioactive indices; number of DNA-synthesizing parenchymal cells; 3 H-thymidine uptake in the nuclei.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: Hypokinesia led to a sharp decrease in number of DNA-synthesizing and dividing hepatocytes, initiation of cell mitoses being depressed the most. Hypokinesia inhibited the rate of DNA synthesis in hepatocytes. It was found that different systems of animal cells react differently to hypokinesia. Inhibition of reproductive processes under hypokinetic conditions was much less marked in connective tissue cells of the hepatic stroma than in hepatocytes, and it was not demonstrable in epithelial cells of small intestinal cryptae. There was no decrease in rate of reproduction of the most intensively multiplying cells of the first third of the cryptae under the influence of hypokinesia, whereas the cells in the second third of the cryptae, which are characterized by less intensive reproduction, presented a decline of mitotic indices at some times of day under experimental conditions.

SOURCE: Space Biology and Aerospace Medicine 12(1): 67-78, 1978

AUTHOR(S): Rosecrans, J.A. and J.J. De Feo

EXPERIMENT TITLE: The Interrelationships Between Chronic Restraint Stress and Reserpine Sedation

SUBJECTS: Male albino Sprague-Dawley rats (150-160 gm)

AREA OF STUDY: Pharmacology

OBJECTIVES: To study interrelationships of pituitary-adrenal axis and brain neurohumoral agents with behavior sequenced during reserpine treatment

PROTOCOL: Four groups: 1) control (unstressed) - received 1 ml/kg ip of the reserpine vehicle daily; 2) control stress - received 1 ml/kg ip of reserpine vehicle and were subjected to daily forced restraint; 3) reserpine control (unstressed) - received 1 mg/kg reserpine ip daily; 4) reserpine stress - received 1 mg/kg reserpine ip daily and were subjected to daily forced restraint. Testing: 1, 6, 12, 18, 24 and 32 days. Rats were restrained daily for a period of 3 hr by tying them dorsally to specially constructed boards. Restraint stress was initiated 5 hr following administration of reserpine or its vehicle and the animals were sacrificed immediately following release. Measurements: organ weights; urine volume; serum corticosterone, brain serotonin, and norepinephrine (NE) levels.

IMMOBILIZATION METHOD: Tied dorsally to board

RESULTS: Reserpine prevented rats from adapting to stress, resulting in 50% mortality; controls adapted both physiologically and behaviorally. For initial excitation associated with restraint, there were also increased serotonin (5-HT) and decreased NE levels. Stressed controls became less excitable as experiment progressed and brain amines returned to normal levels. Reserpine stressed rats were more easily handled at first, but became more excitable and difficult to handle as experiment progressed. Reserpine controls experienced progressive depletion of brain NE to almost complete exhaustion. 5-HT levels were also decreased but reached a constant level.

SOURCE: Archives Internationales de Pharmacodynamie et de Therapie
157(2): 487-498, 1965

AUTHOR(S): Rosemeyer, B. and B. Wallner

EXPERIMENT TITLE: Changes in Bone Formation Under Immobilization and Remobilization Animal Experiments Using ^{45}Ca and Tetracycline Labelling

SUBJECTS: 18 Adult rabbits

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Three groups of 6 animals each: 1) controls; 2) immobilized for 12 wk; 3) immobilized for 12 wk and remobilized for 20 wk. The rear extremity of the rabbits was immobilized by plaster of Paris casts. At the end of the test period the animals were sacrificed by an overdose of Nembutal. Tetracycline tagging was performed by a four-fold labelling at 4 wk interval (20 mg/kg body weight), radioactive tagging took place by a single injection of 100 μCi /300 gm body weight of ^{45}Ca with an incorporation time of 48 hr. The 12th vertebra and coxal femur ends were removed from the animals on both sides. The spongiosa of the vertebra and that of a cross-section at the transition from the upper femur to the femur neck were studied.

IMMOBILIZATION METHOD: Plaster of Paris cast

RESULTS: After immobilization there was no significant change in the intensity of ^{45}Ca incorporation in the vertebra. In the neck of the femur a slight reduction in tetracycline labelling was found. A definite decrease in ^{45}Ca labelled Spongiosa surfaces was found in the histoautoradiogram. In the first stages of remobilization the bone formation was found to be increased and became normal in a later stage. Of tetracycline labelled remobilized animals, there was a definite increase in bone formation in the neck of the femur lasting up to the 16th wk. At many places multiple labelling was noted. The individual labelling were separately defined and enclose newly formed bone tissues. The ^{45}Ca labelling undertaken on the 20th week of remobilization indicated a normal ^{45}Ca incorporation.

SOURCE: Archiv fuer Orthopaedische und Unfall-Chirurgie 83: 1-8, 1975

AUTHOR(S): Rosenquist, J. B.

EXPERIMENT TITLE: Skeletal Fluorosis in Immobilized Extremities

SUBJECTS: Rabbits, male and female (7 wk old)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Under anesthesia, the sciatic nerve of 1 hind limb was severed in order to produce partial paralysis; the leg was then padded with a strip of polyvinyl and immobilized by an external fixation device extending below the wrist joint and above the knee joint, the extremity being in a straight position. The animals were given 10 mg of fluoride per kg of body weight per day during 12 wk. The animals were then killed by an overdose of sodium pentobarbital, and the femora and tibiae freed from soft tissues. Samples were obtained from identical parts of the respective bones. Measurements: bone thickness of the femur, average cortical thickness, relative cortical thickness, fluoride determination.

IMMOBILIZATION METHOD: External fixation device

RESULTS: Thirteen femora were of normal appearance without signs of exostosis formation. In 3 cases, the diaphysis of the experimental femur was covered on its ventral and distal parts by a periosteum that was thicker than that on its control pair. All experimental femora showed considerable periosteal bone formation at the lateral and medial or ventral aspects of the cortex. This bone formation was accompanied by resorption in adjacent areas in 7 out of 8 animals. The femoral cortex was thickened. In the distal part of the tibia, exostatic trabecular bone formation was seen in 4 experimental tibiae. Intracortical bone resorption was seen. The cortices of the experimental femora were significantly thicker than those of the controls. The fluoride concentration was the same in the 2 parts of each femur analyzed and with regard to treatment, there was no difference between the femora.

SOURCE: Acta Pathologica et Microbiologica Scandinavica. Section A: Pathology 83: 678-682, 1975

AUTHOR(S): Rosenzweig, S. and F.M. Blaustein

EXPERIMENT TITLE: Cleft Palate in A/J Mice Resulting From Restraint and Deprivation of Food and Water

SUBJECTS: A/J Mice

AREA OF STUDY: Reproductive

OBJECTIVES: In title

PROTOCOL: Mice were restrained in a wire mesh screen on day 14 of pregnancy for a 24- or 48-hr period; restrained and unrestrained mice were further divided so that half were fasted and half got food and potato. Controls were given food and water throughout pregnancy. Diet: mouse breeder chow; potato; water ad libitum.

IMMOBILIZATION METHOD: Wire mesh screen

RESULTS: 48-hr restraint sharply increased cleft palate and resorption rates. Fasting alone induced a significant cleft palate rate. Restraint and fasting together markedly increased the cleft palate frequency that was produced by either treatment alone. Highly significant differences occurred between the restraint-fasted group compared to the other groups.

SOURCE: Teratology 3(1): 47-52, 1970

AUTHOR(S): Rossi, G., S. Bonfils, F. Lieffogh, and A. Lambling

EXPERIMENT TITLE: New Technique for Producing Gastric Ulcerations in the White Rat: The Ulcer of Constraint

SUBJECTS: Female white Wistar rats (130-150 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Rats were fitted with flexible wire mesh under light anesthesia; the rats' paws were attached to each other, two by two, by means of a strip of adhesive tape. The animal was suspended horizontally in a burette stand in such a way that its paws did not touch the ground. Then 2.5 cc physiological salt solution was injected into each rear paw. Following immobilization for 20 hr and injection, rats were killed. Rats received no food or water.

IMMOBILIZATION METHOD: Flexible wire mesh

RESULTS: Five of 50 rats died during the course of the experiment; 2 as early as the 6th hr, showing signs of gastric ulceration. 42 of 44 rats showed unmistakable gastric ulceration; the other 2 suffered from tiny lesions, but a considerable quantity of blood was found in their stomachs. Ulcerations were seated on the glandular portion of the stomach or ventricle, in multiples, and of unequal size.

SOURCE: Comptes Rendus des Seances de la Societe de Biologie et de ses Filiales 150: 2124-2126, 1956

AUTHOR(S): Rothman, R.H. and S. Slogoff

EXPERIMENT TITLE: The Effect of Immobilization on the Vascular Bed of Tendon

SUBJECTS: 16 New Zealand white rabbits (5 lb)

AREA OF STUDY: Circulatory; Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Immobilization: 6 wk, single hip spica cast applied to 1 hind limb. The unimmobilized limb served as a control. 10 ml of venous blood were removed after immobilization period, mixed with 3 cc of acid citrate dextrose solution, then mixed with 300 μ c of Cr^{51} (sodium chromate) for labeling purposes. Erythrocytes were then reinjected into subjects for 1 hr, after which animals were sacrificed, and 1 ml of blood removed. Measurements: tendon and muscle capillary beds, calculated from gamma emission (counts per minute) and weights of tendo Achillis and biceps femoris.

IMMOBILIZATION METHOD: Cast

RESULTS: A significant decrease occurred in the capillary bed volume in the tendon tissue; the muscle capillary bed showed no significant change. The capillary bed in the tendon of the immobilized limb showed an average of 1.125×10^{-3} ml per gram tendon; that of control averaged 1.846×10^{-3} . The immobilized muscle capillary volume was 2.88×10^{-3} ml per gram, that of control 2.64×10^{-3} .

SOURCE: Surgery, Gynecology and Obstetrics 124(5): 1064-1066, 1967

AUTHOR(S): Roy, S.

EXPERIMENT TITLE: Ultrastructure of Articular Cartilage in Experimental Immobilization

SUBJECTS: 22 Male rabbits (1 yr old)

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: The right knee joint of each rabbit was immobilized in plaster of Paris in a position midway between flexion and extension. The hip and ankle joints on the same side were also included in the plaster to ensure full immobilization of the knee joint. The left knee served as a control. 2 or 3 rabbits were killed after 3, 5, 10, 21, 42, 63, 84 and 168 days of immobilization. Prior to killing, the articular cartilage was removed from the test and control knee joints.

IMMOBILIZATION METHOD: Plaster of Paris cast

RESULTS: Degenerative changes in chondrocytes of the superficial and middle zones occurred after 10 days of immobilization and became increasingly severe in later samples. Necrosis of many chondrocytes of the superficial and middle zones followed, along with loosening of matrix and fragmentation of collagen. Degenerative changes and necrosis appeared earlier and were much more pronounced in cartilage specimens from areas that were in contact with the opposing cartilage at the time of immobilization.

SOURCE: Annals of the Rheumatic Diseases 29: 634-642, 1970

AUTHOR(S): Rozanova, V.D. and U.S Shaikemeleva

EXPERIMENT TITLE: The Total Cholesterol Content of the Blood and Tissues of Rodents Developing Under Conditions of Different Motor Activity

SUBJECTS: Adult hares (2.3-3 kg); adult rabbits (2.6-3.2 kg); rats, 1½ mo old; rabbits, 6 mo old

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two Series - I: adult hares (as representative of eurybiontic or high motor activity); adult rabbits (stenobiontic or low motor activity) and 1 mo old rabbits under muscular training for 6 mo of swimming every other day with increasing periods from 3-35 min; II - 3 groups of 1 mo old rats; kept in high activity (swimming); low activity (in close cage); or control (normal) investigated over the developmental period at 3, 7, 10½ and 13½ mo. Measurements: total cholesterol and lecithin in blood and tissues; basal metabolism (Series II).

IMMOBILIZATION METHOD: Not stated

RESULTS: Hares (eurybiontic) had a lower blood cholesterol (12.4%) and higher levels in the muscle and lungs (7% and 25% respectively) than the rabbits. The lecithin content and lecithin-cholesterol index in the blood was almost double that of the rabbits. Daily swimming of developing rats and rabbits led to hypocholesterolemia and an increased cholesterol content in the muscles. Hypodynamia caused hypercholesterolemia and hypolecithinemia and a decrease of cholesterol in the muscles and lungs.

SOURCE: Zhurnal Evolyutsionnoi Biokhimii i Fiziologii 10(2): 158-163, 1974

AUTHOR(S): Rozanova, V.D., T.G. Savkiv, and N.A. Khodorova

EXPERIMENT TITLE: Change in Energy Expenditure and Brain and Adrenal Content of Catecholamines in Rats During Muscular Loading and Hypokinesia

SUBJECTS: Rats

AREA OF STUDY: Endocrine; Muscular

OBJECTIVES: In title

PROTOCOL: Seven groups under observation from 1-7 mo of age: 1) female controls; 2) male controls; 3) females developing under physical loads of running; 4) males developing under physical loads of running; 5) females developing under loads of swimming; 6) males developing under loads of swimming; 7) males developing under hypokinesia in cages. At ages 1, 4 and 7 mo, body weight and O₂ consumption were measured. At 4 and 7 mo animals were killed. Measurements: muscle mass; muscle protein; noradrenaline in the brainstem; adrenaline and noradrenaline in the adrenal glands; thyroid weight; heart rate.

IMMOBILIZATION METHOD: Cage

RESULTS: The growth and the protein content of control skeletal muscles were higher in males than in females, while the O₂ consumption and the heart rate were lower. There was a reduction of the thyroid gland weight and of catecholamine content in the adrenals at the age of 7 mo. The development of the animals under physical loads increased the growth tempo and protein of skeletal muscles and intensified the degree of reduction of energy expenditure and the heart rate. The hypodynamic condition gave the opposite effect.

SOURCE: Fiziologicheskii Zhurnal SSSR Imeni I M Sechenova 62(2): 304-309, 1976

AUTHOR(S): Rozanova, V.D. and G.A. Antonova

EXPERIMENT TITLE: Activity of Cholinesterases of Blood and Heart in Rats of Different Sex and Age During Muscular Loads and Hypokinesia

SUBJECTS: Mongrel rats

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Seven groups: 1-2) male and female rats trained from 1-3 mo old on treadmill on alternate days with a gradual increase in running time from 5-30 min; 3) males kept hypokinetic in narrow cages from 1-3 mo; 4) males trained from 1-13 mo old on treadmill on alternate days with an increase in running time from 30-100 min. Rats in groups 1-3 were sacrificed at age 3 mo and rats in group 4 at 13. At these same times, rats in 3 control groups (5, 6 and 7) of corresponding age and sex were also sacrificed. Measurements: activity of acetylcholinesterase (Ache) using the substrate of acetylcholinyloride and butyrylcholinesterase (Bche) by the substrate of butyrylcholiniodide in blood plasma and in tissue extracts from the heart.

IMMOBILIZATION METHOD: Cage (narrow)

RESULTS: The activity of Ache and Bche in the blood and heart of 3 and 13 mo old control male rats was lower than in female rats. In 25 mo old animals no sex differences were found in Ache and Bche levels. In 3 and 13 mo old male and female rats under conditions of exercise, the Ache and Bche activity was lower, and in hypokinetic male rats higher than in control animals. In all rats, irrespective of sex, age and motor conditions, Ache and Bche activity decreased from the SA node to the heart apex.

SOURCE: Fiziologicheskii Zhurnal 64(7): 999-1003, 1978

AUTHOR(S): Ruisseau du, P, Y. Tache, P. Brazeau, and R. Collu

EXPERIMENT TITLE: Pattern of Adenohypophyseal Hormone Changes Induced by Various Stressors in Female and Male Rats

SUBJECTS: Male and Female Charles River rats (140-160 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Groups of female and male rats were stressed for 15, 30 min, 1, 2, 4 or 6 hr either by cold exposure (4°C), by forced muscular exercise in a revolving drum or by immobilization in a prone position with their heads inserted in an inverted U-shaped guard soldered to a metal plate and their limbs fastened with adhesive tape to 4 metal strips. At the end of each stress period the rats were killed by decapitation. Trunk blood was collected. Individual plasma samples were assayed in duplicate for growth hormone (GH), prolactin, thyroid-stimulating hormone (TSH), follicle-stimulating hormone (FSH), and luteinizing hormone (LH).

IMMOBILIZATION METHOD: Metal plate with head guard, tape

RESULTS: GH levels in both female and male rats were decreased by the 3 stressing agents. Immobilization in the female and the 3 stressors in the male elicited an early secretory response of prolactin. A more prolonged exposure to stress had an inhibitory influence on plasma prolactin and LH levels in both sexes. FSH concentrations were not modified in females but were decreased in male rats to either 1 of the 3 stressors. In both female and male rats plasma TSH levels rose during cold exposure while they were decreased by forced muscular exercise and by immobilization.

SOURCE: Neuroendocrinology 27(5-6): 257-271, 1978

AUTHOR(S): Ryl'nikov, Yu.P.

EXPERIMENT TITLE: Effect of Hypokinesia on the Lipid Composition of the Blood and Tissues in Rabbits of Different Age

SUBJECTS: 59 Rabbits, 1-1½ yr old (2.5-3 kg), and 2-2½ yr old (3.5-5 kg)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls, for young (1-1½ yr) and older (2-2½ yr) rabbits; 2) young rabbits, hypokinetic; 3) older rabbits, hypokinetic. All hypokinetic animals were kept in tight cages for 30 days. Rabbits investigated for the content of total, ester bound, and free cholesterol and phospholipids in the blood serum on days 1, 3, 5, 10, 15 and 30. All rabbits were killed after 30 days, and the blood, liver, heart, aorta and brain were analyzed. Measurements: total quantity of lipids, cholesterol, sphingomyelins, lecithin, and kephalin.

IMMOBILIZATION METHOD: Cage (tight)

RESULTS: There was an increase in blood, heart, and liver cholesterol, which was greater in the older group, most particularly in the liver, which showed a 5-fold increase. The level of total lipids in the heart and liver increased. The content of lipids containing phosphorus in the heart and aorta decreased at the expense of sphingomyelins, lecithin, and kephalin in the older group and lecithin and kephalin only in the younger group. Hypokinetic exposure in the older age group favored the development of atherosclerosis.

SOURCE: Space Biology and Aerospace Medicine 8(2): 9-15, 1974

AUTHOR(S): Ryzenkov, V.Ye.

EXPERIMENT TITLE: Effect of Central Neurotropic Substances on the Hypophysis-Adrenal Cortex System During the Immobilization of Animals

SUBJECTS: 328 Male guinea pigs (300-400 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Twenty-nine groups: 1) controls, nonrestrained; 2-5) restrained by securing to a flat surface for 5, 12, 24 or 48 hr; 6) immobilized 48 hr + ACTH every 8-10 hr; 7) immobilized, starved + ACTH every 8-10 hr; 8) immobilized, unstarved + ACTH every 8-10 hr; 9) starved for 48 hr; 10-29) immobilized for 48 hr, administered various doses and combinations of neurotropic substances at 8 hr intervals. Measurements: 17-oxycorticosteroid (17-OCS) concentration in blood plasma.

IMMOBILIZATION METHOD: Tied to a flat surface

RESULTS: Increased periods of immobilization resulted in an increase in the 17-OCS concentration in blood plasma. The "central" sedative phenobarbital, as opposed to the "cortical" chloral hydrate, depressed the response of the hypophysis-adrenal system of immobilized guinea pigs. Administration of sodium oxybutyrate and also the combined administration of central m- and n-cholinolytics with small doses of phenobarbital tended to inhibit activation of the adrenal cortex during immobilization. Repeated administration of aminazine decreased activation of the adrenal cortex. The administration of reserpine 12-18 hr before immobilization increased the response of the hypophysis-adrenal cortex system.

SOURCE: Farmakologiya i Toksikologiya 31(5): 545-548, 1968

AUTHOR(S): Sabaev, V.V., V.S. Shashkov, P.V. Sergeyev, V.A. Chistyakov,
and M.A. Seydametov

EXPERIMENT TITLE: Effect of Radioprotectants on the Functional State
of Histo-Hematic Barriers in Restricted Animals

SUBJECTS: 125 Sexually mature white male rats (170 + 30 gm)

AREA OF STUDY: Circulatory; Pharmacology

OBJECTIVES: In title

PROTOCOL: Two groups: 1) rats injected with mexamine (10 mg/kg) and cystamine (25 mg/kg) 30 min before killing; 2) rats subjected to 10-day hypokinesia in cages and then injected with the same drugs as group 1. The permeability indicator used was albumin I^{131} (20 μ g/kg) which was injected in both series 60 min before killing. Measurements: radio-activity in blood, cerebral tissue, heart, lungs, liver, kidneys, spleen, thymus, submaxillary lymph nodes, adrenals, hip and back muscles.

IMMOBILIZATION METHOD: Cage

RESULTS: Injection of radioprotectants in intact animals increased transport of albumin I^{131} through the hemato-encephalic barrier, against the background of hypokinesia it did not cause similar shifts.

SOURCE: Space Biology and Medicine 6(1): 7-12, 1972

AUTHOR(S): Saiki, H., M. Nakaya, Y. Sugita, and M. Kamachi

EXPERIMENT TITLE: Metabolic and Hormonal Mechanisms of Mineral Metabolic Adaptation to Induced Hypokinetics in Rats

SUBJECTS: Albino rats

AREA OF STUDY: Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: Two groups: 1) rats were subjected to hypokinesia by the suspension method for 1, 2, 4 and 5 wk; 2) rats were injected im with various dosages (25-50 mcg/100 gm) of aldosterone and effects were determined during preexposure and each phase of hypokinetic exposure in noninjected and antialdosterone-injected rats. The antialdosterone substances, actinomycin-D and tetracycline, were used. Measurements: oxygen consumption, potassium (K^+), sodium (Na^+), and calcium (Ca^{2+}) contents of skeletal muscle, heart, liver, brain, and kidneys.

IMMOBILIZATION METHOD: Suspension

RESULTS: A new plateau in urinary K^+ excretion was seen during wk 3, after a transient decrease during wk 1. The steady plateau formed served to divide the hypokinetic exposure period into 2 phases: stabilized and prestabilized. Actinomycin-D caused marked decrease in the urinary excretion rates of K^+ and Na^+ . Simultaneous administration of actinomycin-D and aldosterone produced no antagonistic action for K^+ excretion, but aldosterone increased Na^+ retention. As the dosage of tetracycline was increased, lesser amounts of K^+ were excreted, and about the same relationship was seen for the urinary excretion of Na^+ .

SOURCE: Aviation Space and Environmental Medicine 47(8): 846-852, 1976

AUTHOR(S): Sander, L.D., A.M. Chandler, and L.R. Johnson

EXPERIMENT TITLE: Changes in Liver and Gastric Mucosal Hexosamine Synthesis After Restraint

SUBJECTS: Male Stanley-Gumbreck rats (250-300 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: All animals were fasted 18 hr before immobilization. Six to 8 rats at a time were placed in individual cages and then placed in a cold room (2-4°C). An equal number of control animals were maintained at room temperature in larger cages. Groups: 1) untreated, but immobilized for 1½, 3 and 20 hr and killed at various times afterward; 2) bilaterally adrenalectomized and sham-operated rats were killed after 1-hr immobilization; and 3) atropinized rats were injected sc with 5 mg/kg atropine sulfate immediately before 3-hr immobilization. Measurements: glucosamine synthetase; gastric oxyntic gland mucosa and liver enzymes.

IMMOBILIZATION METHOD: Cage (individual)

RESULTS: 3-hr restraint produced 100% frequency of lesion formation associated with decreased enzyme activity in oxyntic gland mucosa ($70.1 \pm 5.9\%$ of control) and liver ($25.2 \pm 5.2\%$ of control); enzyme activity returned to control level in the stomach 9-hr postrestraint and in the liver 21-hr postrestraint. 1½-hr restraint decreased oxyntic gland mucosa enzyme activity to $21.0 \pm 9.8\%$ of control, although lesion formation frequency was only 62.5%; liver enzyme activity was $51.3 \pm 12.8\%$ of control. UDP-N-acetylhexosamines, feedback inhibitors of this enzyme, were not altered in either tissue. Adrenalectomy which increased the damage frequency after 1-hr restraint, enhanced the decreases in enzyme activity in both tissues; atropine sulfate, which decreased damage frequency after 3-hr restraint, had no significant effect on the enzyme.

SOURCE: Gastroenterology 68(2): 285-293, 1975

AUTHOR(S): Sanyal, A.K., C.R. Banerji, and P.K. Das

EXPERIMENT TITLE: Banana and Restraint Ulcers in Albino Rats

SUBJECTS: Male Albino rats (140-170 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental, for this group, the usual diet was replaced by powdered, air-dried unripe banana pulp 48 hr before fast. Following the 18 hr fast with free access to water, the rats were immobilized. After immobilizing their limbs by adhesive tape, the rats were put individually into a tightly fitting metal corset; the tail was also immobilized by fixing it to the outer wall of the corset. After 24 hr restraint, the animals were killed and their stomachs removed. Measurements: incidence of ulcers.

IMMOBILIZATION METHOD: Metal corset and adhesive tape

RESULTS: Superficial mucosal ulcers in the glandular portion of the stomach and frank intragastric hemorrhage were found in 80% of the controls; microscopically there was mucosal erosion, dilatation and congestion of the blood vessels and sometimes edema of the mucosal and submucosal layers. In banana-fed rats, small ulcers were present in only 13.3% ($p < .01$), accompanied by frank intragastric hemorrhage. In all other rats, the stomach showed microscopically either normal appearance or slight vascular dilatation.

SOURCE: Journal of Pharmacy and Pharmacology 15(11): 775-776, 1963

AUTHOR(S): Sapira, J.D., R. Lipman, and A.P. Shapiro

EXPERIMENT TITLE: Effect of Restraint on Free Fatty Acid Mobilization
in Rats

SUBJECTS: Male albino Holtzman rats (170-250 gm)

AREA OF STUDY: Metabolism and Energy Exchange; Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control rats; 2) experimental rats were restrained in wire-mesh cages for 9, 18 or 24 hr. Both groups were fasted during the experimental period. Following restraint or of fasting only, rats were anesthetized with ether and given either 0.1 mg/kg L-norepinephrine via tail vein or an equal volume of saline only; they were then bled by cardiac puncture. Measurement: free fatty acid (FFA).

IMMOBILIZATION METHOD: Cage (wire mesh)

RESULTS: A slight increase in plasma levels of FFA seemed to occur during the first 18 hr of restraint; the change was not statistically significant. With L-norepinephrine there was an obvious decrease in FFA reserve with increasing length of restraint. In fasted but unrestrained rats, FFA levels after L-norepinephrine were not significantly different from each other at different time periods or from baseline. For 12 rats fasted for 48 hr and then injected with L-norepinephrine, the FFA reserve was the lowest value for any fasting unrestrained group. Neither release from 6-hr restraint nor ad libitum refeeding for the same period replenished the FFA pool.

SOURCE: Psychosomatic Medicine 27(2): 165-170, 1965

AUTHOR(S): Saryyeva, Z.A.

EXPERIMENT TITLE: The Effect of Hypodynamia and Hypokinesia on the Arterial Bed of the Rabbit's Hind Legs

SUBJECTS: Rabbits (2300-2500 gm)

AREA OF STUDY: Muscular; Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 5 control rabbits; 2) 15 experimental rabbits were kept in special cages that severely restricted their movements. The animals were examined at 1, 2, 3, 4, 6 and 24 wk. The vessels of the hind legs were studied by injecting the arterial bed with Hauch's roentgen opaque medium and x-raying both hind legs.

IMMOBILIZATION METHOD: Cage

RESULTS: After 1 week, noticeable atrophy of the leg muscles was observed. The width of major femoral vessels was not altered. After 2 wk, there was further atrophy of posterior and anterior femoral muscles and major femoral vessels remained unchanged. After 3-4 wk, atrophy increased along with straightening of arteries, poor demonstration of anastomoses between their branches and poor intramuscular network. After 6 wk, atrophy progressed and major femoral vessels presented some dilatation. The arteries of the leg, foot and their branches were constricted. After 24 wk, the muscle mass of the thigh and leg was considerably reduced. The main vessels were somewhat wider than at 6 wk while they were narrower in the foot.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii No. 11: 105-109, 1971

AUTHOR(S): Savik, Z.F. and A.D. Cherkai

EXPERIMENT TITLE: Morphological Analysis of the Functional State of the Vascular Endothelium in Hypokinesia

SUBJECTS: Rats

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) rats immobilized in small cages from 1-60 days. At various times, the capillary endothelium of the soleus muscles was studied on electron micrographs. Measurements: the length of the free surface of the capillary endothelium and the length of their inner and outer circumferences.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: There was an increase in the length of the free surface of the capillaries between the 1st and 60th day of hypokinesia. On the 1st day of hypokinesia there was a marked increase in the exchange of materials between the endothelial cell and the pericapillary tissue elements and between the endothelial cell and the blood plasma.

SOURCE: Bulletin of Experimental Biology and Medicine 78(9): 1087-1089, 1974

AUTHOR(S): Schauer, A., E. Kunze, G. Feifel, W. Permanetter, and P. Fraps

EXPERIMENT TITLE: Increased Histidine and Dopa Decarboxylase Activity in the Rat Stomach During Restraint Ulcer Formation

SUBJECTS: Female Wistar rats (180-200 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: In two chronologically separate experimental series, experimental rats were restrained for up to 30 hr at 22°C by tightly enclosing the body in a plaster cast. During restraint the animals received no food with water freely available; control animals had free access to food and water. Groups of 10 restrained rats and corresponding control animals were decapitated at 2-hr intervals beginning 3 hr after the onset of restraint; the stomachs were removed. Measurements: mucosal defects; histidine decarboxylase; dopa decarboxylase.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: After 3 hr, histidine decarboxylase showed a continuous increase in activity and attained a maximum of more than twice the activity in the controls between 9-11 hr respectively. Dopa decarboxylase was only moderately raised until 11-13 hr after the onset of restraint and revealed twice the activity after 13-15 hr. Subsequently, the activity of both amino acid decarboxylases decreased and dropped to below the normal level after 21 hr.

SOURCE: Digestion 11: 12-24, 1974

AUTHOR(S): Schramm, H.

EXPERIMENT TITLE: The Effect of Various Drugs on Experimentally Induced Ulcers in Immobilized Rats

SUBJECTS: Male and female Wistar rats, 5-15 mo old (140-340 gm)

AREA OF STUDY: Digestive; Pharmacology

OBJECTIVES: In title

PROTOCOL: Two Series: I - Female rats were fasted for 24 hr, immobilized in a wire mesh corset with the protruding feet tied together then suspended from a rigid support for 24 hr. Groups: 1) controls, not immobilized but subjected to fasting; 2) injected with saline prior to immobilization; 3) treated with propaphenine, prothazine, eustigmine, atropine, depot-pholedrine, depot-padutine or papaverine. Series II - Male rats were immobilized as in series I. Groups: 1) administered oestraside with and without immobilization; 2) oestraside treated before immobilization and administration of propaphenine; 3) propaphenine prior to immobilization at 15°C; 4) controls. Measurements: ulcers of the glandular stomach.

IMMOBILIZATION METHOD: Suspended in wire mesh corset

RESULTS: Nonimmobilized controls did not develop ulcers. Fasting, weight differences and light and bell signals had no effect on ulcer formation. Ulcer frequency was significantly higher in immobilized female rats, 85% as compared to 10%. Immobilized male rats pretreated with oestraside had increased ulcer rates, but oestraside treatment alone did not influence ulcer formation. With the administration of propaphenine, papaverine and atropine, there was a significant decrease in ulcer frequency in female rats. As a result of prothazine administration and also decreased temperature all rats developed ulcers. Eustigmine had no significant effect.

SOURCE: Deutsche Zeitschrift für Verdauungs- und Stoffwechselkrankheiten 28(5/6): 305-312, 1968

AUTHOR(S): Schwille, P.O., W. Schellerer, H. Steiner, and M. Reitzenstein

EXPERIMENT TITLE: Rat Gastric Mucosal Oxygen Tension, Ulcer Index, Plasma Gastrin and Glucagon Following Restraint Stress. Influence of Vagotomy, Splanchnicotomy and Exogenous Secretin

SUBJECTS: Male SPF Wistar rats (200 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: 6-7 days prestress, rats were: 1) left intact (controls); 2) sham operated, 50 mg/kg ip pentobarbital anesthesia; or 3) subjected to truncal vagotomy (VT) by microsurgery with and without pyroplasty. Following 18 hr of fasting with access to drinking fluid, rats were restrained (8 and 24 hr) with wire loops. Secretin was sc injected either prophylactically during restraint (5 times, 1, 2, 4, 5, 16 U/kg) or therapeutically following termination of restraint (5 times, 4 or 8 U/kg). Controls received equal volumes of 0.15 m Na-chloride. Under anesthesia, blood was drawn from the abdominal vena cava. Measurements: pO_2 ; glucagon; gastrin; ulcer index.

IMMOBILIZATION METHOD: Wire loops

RESULTS: Neither prior truncal VT, splanchiotomy, nor combined dissection of abdominal autonomic nerves were effective in preventing the stress-mediated fall of mucosal partial oxygen tension of gastric mucosa (pO_2), and the rise in plasma glucagon (pGl). The ulcer index remained elevated and gastrin was essentially unchanged. Prophylactic injection of increasing doses (1, 2, 4, 8, 16 U/kg) secretin maintained microcirculation at pO_2 levels sub-normal for unstressed animals, but brought about a continuous rise in serum gastrin. Up to 8 U/kg pGl was higher than in saline control groups, reaching a peak value with 2 U/kg when the ulcer index showed its nadir. Secretin therapy (4, 8 U/kg) markedly improved both mucosal pO_2 and the ulcer index.

SOURCE: Research in Experimental Medicine 167: 149-158, 1976

AUTHOR(S): Scott, R.A., Jr.

EXPERIMENT TITLE: Chimpanzee Hematologic Alterations During and Following
24 Hours of Restraint

SUBJECTS: 20 Chimpanzees, 27-74 mo old (10-29.7 kg)

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: Thirteen male and 7 female animals were used in 33 and 26 restraint periods, respectively. The chimpanzee subjects, generally in pairs, were restrained for a 24-hr period in a semi-reclining position (in a chair). Hematologic alterations in blood drawn immediately before, immediately after, 24 hr post-, and, for a limited number of cases, 7 days post-restraint were compared. The values were analyzed for significant deviations in relation to age, sex, and duration of restraint. Diet: food and fluid ad libitum. Measurements: red blood cell and white blood cell counts; hemoglobin; white blood cell differential; total eosinophile count; hematocrit; platelets; erythrocyte sedimentation rate.

IMMOBILIZATION METHOD: Chair

RESULTS: Pronounced alterations with restraint occurred in most of the formed elements determined. The elevation of urea nitrogen and protein was indicative of a dehydration state. There was an increase in values immediately after prolonged restraint for the red blood cells, hemoglobin, hematocrit and mature polymorphonuclear leucocytes followed by a decrease in these values 1 day after restraint. The values decreased immediately after restraint for mononuclear lymphocytes, monocytes, and eosinophiles in both sexes and for erythrocyte sedimentation rate in the females. These decreases were followed by increases 1 day after restraint. Differences in sexes existed in hematological alterations during 24 hr of restraint.

SOURCE: Aeromedical Research Laboratory, Aerospace Medical Division,
Holloman AFB, New Mexico, October 1964, 11 pp. (ARL-TR-64-13)

AUTHOR(S): Scott, R.A., Jr.

EXPERIMENT TITLE: Chimpanzee Serum Biochemic Alterations During and Following 24 Hours of Restraint

SUBJECTS: 20 Chimpanzees, 28-74 mo old (10-29.7 kg)

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: Thirteen male and 7 female animals were used in 33 and 26 restraint periods, respectively. The chimpanzee subjects, generally in pairs, were restrained for a 24-hr period in a semi-reclining position (in a chair). Serum values drawn immediately before, immediately after, 24 hr post-, and, for a limited number of cases, 7 days post-restraint were compared. The values were analyzed for significant deviations in relation to age, sex, and duration of restraint. Diet: food and fluid ad libitum. Measurements: urea nitrogen; creatinine; total protein; sodium, potassium; carbon dioxide; chloride; calcium; inorganic phosphorus; total cholesterol; free cholesterol.

IMMOBILIZATION METHOD: Chair

RESULTS: Differences between sexes in serum biochemic changes during 24 hr of restraint seemed to exist at prepubertal ages. The most pronounced changes during restraint occurred in serum potassium, inorganic phosphate, and total cholesterol level.

SOURCE: Aeromedical Research Laboratory, Aerospace Medical Division, Holloman AFB, New Mexico, October 1964, 21 pp. (ARL-TR-64-12)

AUTHOR(S): Scott, R.A., Jr.

EXPERIMENT TITLE: Chimpanzee Urine Biochemic Alterations During 24 Hours of Restraint

SUBJECTS: 20 Chimpanzees, 27-74 mo old (10-29.7 kg)

AREA OF STUDY: Fluid and Electrolyte; Endocrine

OBJECTIVES: In title

PROTOCOL: Thirteen male and 7 female animals were used in 33 and 26 restraint periods, respectively. The chimpanzee subjects, generally in pairs, were restrained for a 24-hr period in a semi-reclining position (in a chair). Urine samples were collected at 6-hr intervals during the restraint period. Urine biochemic values were analyzed for significant deviations in relation to age, sex, urine volume, and duration of restraint. Diet: food and fluid ad libitum. Measurements: creatinine; sodium; potassium; chloride; calcium; epinephrine; norepinephrine; total catecholamines; 17-hydroxysteroids; 17-ketosteroids; urine volume.

IMMOBILIZATION METHOD: Chair

RESULTS: For males, urine values for potassium, epinephrine, total catecholamines, and the urine volume were decreased as the restraint period increased. Pronounced decreases for potassium, 17-hydroxysteroids, and the urine volume occurred with increases in the duration of restraint in females. Levels of chloride, norepinephrine and 17-ketosteroids were directly related to the duration of restraint in the female chimpanzees.

SOURCE: Aeromedical Research Laboratory, Aerospace Medical Division, Holloman AFB, New Mexico, October 1964, 15 pp. (ARL-TR-64-14)

AUTHOR(S): Sedlakova, A., E. Ahlersova, I. Ahlers, and M. Praslicka

EXPERIMENT TITLE: Effect of Combination of Continuous Gamma Irradiation and Restraint on Serum and Tissue Lipids in Rat

SUBJECTS: Male Wistar rats (10-12 wk old)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Experimental groups of 8-10 rats each were subjected to continuous gamma irradiation from Co⁶⁰ source. Daily exposure was 60 R, total 1500 R; 2 hr after irradiation, they were restrained for 90 min in specially constructed boxes. Six groups: 1) restrained immediately after irradiation; 2) irradiation, nonrestrained, analyzed immediately; 3) restrained 1 wk after irradiation; 4) irradiation, analyzed 1 wk later, nonrestrained; 5) and 6) controls. At the end of each experiment, animals were decapitated. Diet: Larsen mixture and water ad libitum. Measurements: serum and tissue lipid fractions; blood glucose level. Group 1 was compared to group 2, group 3 to group 4.

IMMOBILIZATION METHOD: Box

RESULTS: A significant increase of serum esterified and free fatty acids, phospholipids and cholesterol and of blood glucose occurred in rats restrained immediately after radiation. Liver concentrations of free fatty acids increased, concentrations of esterified free fatty acids and cholesterol in heart muscle decreased. Triglycerides and free fatty acids increased in the thymus, and cholesterol decreased in adrenals. A week after irradiation, restraint had a similar effect. Serum triglycerides increased and cholesterol decreased. Blood glucose rose significantly. Elevation of serum free fatty acids was not significant, and no serious changes in the heart muscle occurred.

SOURCE: Biologia 26: 909-913, 1971

AUTHOR(S): Selye, H., B. Tuchweber, and G. Gabbiani

EXPERIMENT TITLE: Protection by Restraint Against Parathyroid Hormone Intoxication

SUBJECTS: 40 Female Sprague-Dawley rats; 20 young (95-105 gm),
20 adult (193-207 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Two series of experiments: 1) rats weighing 95-105 gm; 2) rats weighing 193-207 gm. Rats were sc injected with parathyroid extract (100 USP units in young rats, 125 USP units in adult rats) twice daily on the 1st and 2nd days of the experiment. Restraint applied for 24 hr on 1st day, starting 2 hr after 1st injection. Animals given food and water throughout experiment; killed with chloroform on the 6th day. Control rats in each series given parathyroid injections only (no restraint). Diet: Purina Laboratory Chow and tap water. Measurements: soft-tissue calcification of heart and kidney; degree of bone lesions; kidney weight.

IMMOBILIZATION METHOD: Board

RESULTS: Findings similar in young and adult rats. Parathyroid extract injections without accompanying restraint produced severe osteitis fibrosa with extensive bone destruction in every animal along with severe calcification of heart or cardiac vessels (in adults only), maximal nephrocalcinosis and kidney enlargement. In contrast, concurrent exposure to restraint produced no trace of osteitis fibrosa, calcification of heart or kidney tissues, or kidney enlargement.

SOURCE: Acta Endocrinologica 45 (Suppl.90): 203-209, 1964

AUTHOR(S): Selye, H., G. Gabbiani, and B. Tuchweber

EXPERIMENT TITLE: Protection by Restraint Against Parathyroid-Extract Intoxication in Absence of the Adrenals

SUBJECTS: 60 Female Sprague-Dawley rats (195-210 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Six groups: 1) no treatment (controls); 2) restraint; 3) injected with desoxycorticosterone (DOC) and cortisol (COL); 4) restraint plus injected with DOC and COL; 5) adrenalectomy plus injected with DOC and COL; 6) restraint plus adrenalectomy plus injected with DOC and COL. Parathyroid extract was given sc to all groups on days 6 and 7. Restraint applied for 17 hr on the 6th day starting 1 hr after the 2nd injection of parathyroid extract. Food and water not restricted. Rats killed on the 10th day for tissue analysis. Diet: Purina Laboratory Chow and tap water. Measurements: degree of osteitis fibrosis; calcification of heart and kidney; kidney weight; mortality.

IMMOBILIZATION METHOD: Board

RESULTS: Rats exposed to restraint stress showed no soft-tissue calcification or suppression of renal enlargement. The rate of mortality was significantly influenced by restraint only in adrenalectomized animals. In groups 1 and 3 (not restrained) nephrocalcinosis induced by parathyroid extract injection was not prevented by corticoid injections alone. Nephrocalcinosis and associated increase in renal weight did not appear in animals subjected to restraint. Among adrenalectomized rats not exposed to restraint (group 5) only 1 animal survived to the end of the experiment. Animals which died earlier showed maximal renal calcification and nephrocalcinosis, while the corresponding adrenalectomized and restrained rats (group 6) showed no such symptoms, and survived longer. Osteitis fibrosa was also virtually absent in all groups exposed to restraint.

SOURCE: American Journal of Physiology 207: 573-576, 1964

AUTHOR(S): Semb, H.

EXPERIMENT TITLE: The Breaking Strength of Normal and Immobilized Cortical Bone From Dogs

SUBJECTS: 12 Adult mongrel dogs

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: In 9 dogs, one fore leg was immobilized with plaster casts; in 3 dogs, one fore leg was paralyzed by brachial plexus resection. Immobilization was 4-112 days. Dogs were killed by Nembutal overdose. Standard specimens were prepared from different sectors of the distal part of immobilized and untreated radial bones.

IMMOBILIZATION METHOD: Plaster casts; Denervation

RESULTS: Microradiographs from the ends of the sample region showed evident signs of osteoporosis consisting of increased numbers of resorption cavities and/or reduced volume of trabecular bone, when the immobilization periods were at least 3 weeks. There were no significant mean differences of the breaking strength in control and immobilized bone.

SOURCE: Acta Orthopaedica Scandinavica 37: 131-140, 1966

AUTHOR(S): Semb, H.

EXPERIMENT TITLE: The Chemical Composition of Microscopic Cortical Bone Structures from Immobilized Bones in Dogs

SUBJECTS: 4 Adult mongrel dogs

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 3 dogs, plaster cast applied to one fore limb with the elbow joint at about 90° flexion and the radiocarpal joint at 90° volar flexion; 2) 1 dog, one hind limb was immobilized with the knee joint at 90° flexion and the tibiatarsal joint at a right angle to the tibial shaft. Dogs were immobilized from 4 to 7 wk; following which they were killed with an overdose of Nembutal. From immobilized and control metacarpal or metatarsal bones, cross-sections were cut out from the middle of the diaphyses. Periosteal lamellar bone, endosteal lamellar bone, and highly mineralized Haversian systems were chosen for analysis. Measurements: calcium; phosphorus; nitrogen; density.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: Slightly but significantly decreased concentrations of calcium, phosphorus, and nitrogen were found in restrained periosteal lamellar bone. No definite differences in the composition of restrained and normal endosteal lamellar bone and highly mineralized Haversian systems were found. In restrained periosteal lamellar structures, the percentage of (w/w) calcium content and the Ca/P weight ratios were significantly decreased.

SOURCE: Acta Societatis Medicorum Upsaliensis 71(5-6): 197-206, 1966

AUTHOR(S): Semb, H.

EXPERIMENT TITLE: The Effect of Immobilization on the Phosphate
Turnover of Bone-Marrow Plasma in Dogs

SUBJECTS: 12 Adult mongrel dogs

AREA OF STUDY: Skeletal; Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 10 dogs, plaster cast applied to one fore-limb with the elbow joint at about 90° flexion and the radiocarpal joint at 90° volar flexion; 2) 2 dogs, one fore-limb was paralyzed by brachial plexus resection. Dogs were immobilized from 4 to 112 days. 4 days prior to the end of immobilization, 11 dogs were given 0.5 mC P^{32} /kg iv; the 12th dog was given 0.3 mC P^{32} /kg iv at the end of 25 days immobilization. Diet: dry food. Measurements: inorganic phosphorus; specific phosphorus activity.

IMMOBILIZATION METHOD: Plaster cast; Denervation

RESULTS: Inorganic phosphorus concentration in intramedullary plasma increased at the beginning of immobilization, but decreased significantly after about 3 wk of disuse. 4 days after isotope administration, phosphorus specific activity was the same in plasma from both normal and immobilized bones, but arterial plasma specific activity was significantly higher than bone marrow plasma specific activity. For the 12th dog, initial radioactivity was higher in plasma from the immobilized bone.

SOURCE: Acta Societatis Medicorum Upsaliensis 71(5-6): 207-215, 1966

AUTHOR(S): Semb, H.

EXPERIMENT TITLE: Experimental Disuse Osteoporosis. I. Acid-Base Status in Intramedullary Blood from Immobilized Rabbit Tibial Bones

SUBJECTS: 44 Rabbits (2-2.5 kg)

AREA OF STUDY: Skeletal; Blood

OBJECTIVES: In title

PROTOCOL: Plaster cast was applied to the left hind limb from the groin distally over the toes; the knee joint in flexion and the tibiotarsal joint in an intermediate position. The right hind limb served as a control. Rabbits were immobilized from 2 to 35 days. 15 untreated normal rabbits used in a control investigation. The acid-base status in intramedullary blood from the distal part of the rabbit's tibiae was investigated, and x-rays were taken. Measurements: pH; pCO_2 ; standard bicarbonate.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: The pH of the intramedullary blood from the immobilized tibia differed in most cases from that of the contralateral control tibia. In shorter immobilization periods, no definite relationship was observed. After more than 9 days immobilization, the intramedullary blood pH increased in the immobilized tibiae; this was linked to decreased carbon dioxide tension in the blood. The pCO_2 of blood from immobilized tibiae was lower than the control bone in most cases, but standard bicarbonate values did not show any definite differences.

SOURCE: Acta Societatis Medicorum Upsaliensis 71(1-2): 83-95, 1966

AUTHOR(S): Semb, H.

EXPERIMENT TITLE: Experimental Disuse Osteoporosis. II. Oxygen Saturation and Oxygen Tension in Intramedullary Blood from Immobilized Rabbit Tibial Bones

SUBJECTS: 29 Rabbits (2-2.5 kg)

AREA OF STUDY: Skeletal; Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 23 rabbits - the left hind leg was immobilized (3-32 days) with a padded plaster cast from the groin to the toes, with the tibio-tarsal joint in the intermediate position. After immobilization, the animals were heparinized and anaesthetized with pentobarbital sodium (60 mg/ml). Blood was drawn from the left carotid artery and from the right and left tibia. Oxygen saturation (HbO₂) and oxygen tension (PO₂) were determined; 2) 6 rabbits - the animals were anesthetized with Nembutal and heparinized. The plaster cast was completely removed, and the animal was immobilized recumbent with the legs in symmetric positions, slightly abducted and rotated outwards. The abdomen was opened and the abdominal aorta exposed; a polyethylene catheter was inserted and a mixture of 250 ml India ink and 600 ml saline solution was infused. Hind legs were then removed, the large vessels having been ligated. The legs fixed in 10% neutral formaline solution, the distal ends of the tibiae were decalcified in 10% nitric acid; cross sections of wax-embedded tibiae (about 0.7 mm thick) preparations were examined under a dissection microscope.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: Group 1 - after immobilization periods longer than 10 days highly significantly increased values for the HbO₂ and insignificantly increased values for the PO₂ were demonstrated in intramedullary blood from the immobilized tibia. With shorter periods this tendency was not as clear. Group 2 - after immobilization periods of 2 and 3 weeks, dilated luminae were observed in the intramedullary sinusoids, together with greatly dilated vessel luminae in the cancellous bone tissues in the distal metaphysis of the immobilized tibia. After only 3 days immobilization, the vessel filling was good intramedullarily. No differences of calibre or configuration of the vessels could be observed between the immobilized and control sides.

SOURCE: Acta Societatis Medicorum Upsaliensis 71(1-2): 96-107, 1966

AUTHOR(S): Semb, H.

EXPERIMENT TITLE: The Influence of Immobilization on the Phosphorus Uptake in Microscopic Diaphyseal Bone Structures in Dogs

SUBJECTS: 14 Adult mongrel dogs

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: In 10 dogs, one forelimb was immobilized in plaster cast; in 4 dogs, one forelimb was paralyzed by brachial plexus resection. Immobilization was 4-112 days. 0.5 mC/kg P^{32} was given 4 days before the end of immobilization. 25 mg/kg iv injections of Aureomycin or Terramycin were given at the beginning and 2 days before the end of testing to mark regions where bone was forming during immobilization. Dogs were killed by Nembutal overdose. Diet: dog food. Measurements: phosphorus uptake.

IMMOBILIZATION METHOD: Plaster cast; Denervation

RESULTS: Differing types of cortical bone structure from metacarpal bones showed differing changes in phosphorus uptake during immobilization. There was decreased uptake in periosteal lamellar bone whatever the immobilization duration, and endosteal lamellar bone and highly mineralized Haversian systems during the first 4 wk, returning to normal or increasing in the lamellar bone. There was increased uptake in nongrowing bone at the periphery of resorption cavities during immobilization. Phosphorus uptake was similar in both types of immobilization.

SOURCE: Acta Societatis Medicorum Upsaliensis 71(5-6): 216-226, 1966

AUTHOR(S): Semb, H.

EXPERIMENT TITLE: Plasma Clearance of Sr^{85} by Bone: An Attempt to Study the Rate of Blood Flow Through Normal and Immobilized Bone in Dogs

SUBJECTS: 7 Adult mongrel dogs

AREA OF STUDY: Skeletal; Circulatory

OBJECTIVES: In title

PROTOCOL: Immobilization: 2-28 days; plaster cast applied to one fore-limb, with the elbow joint in semiflexion and the radiocarpal joint at 90° of volar flexion. After preparation of the femoral artery (for collection of arterial blood) and the distal ends of radial bones, Sr^{85} was administered iv. Blood samples were then immediately collected from the cannulated femoral artery and from both radial metaphyses at a frequency of 6-10 tubes; after 10 min circulation was stopped and the animal killed. Measurements: total blood flow, as applied to the uptake of Sr^{85} (counts per gm fresh bone tissue), and the difference of Sr^{85} activity (counts per min per ml) between arterial and bone-marrow plasma; bone sample weight.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: No effect upon the bone blood flow could be demonstrated within 2 wk of immobilization; after 2 wk an increase seemed to occur. Four wk of immobilization produced about a 50% increase of bone blood flow. The ratios between the strontium activity (counts/min per gm fresh bone tissue) in immobilized and normal bone were increased after about 2 wk (increased uptake of Sr^{85}); for shorter periods there were no consistent differences in activity. There was very good agreement between the values obtained from total blood flow through normal bone - values ranged between 25-30 ml/min per 100 gm bone.

SOURCE: Acta Societatis Medicorum Upsaliensis 71(5-6): 227-236, 1966

AUTHOR(S): Semiginovský, B., B. Jakoubek, M. Kraus, and R. Erdösová

EXPERIMENT TITLE: Effect of Restraint Stress on the Oxygen Consumption and [^{14}C]Leucine Incorporation into Brain Cortex Slices of Rats

SUBJECTS: 20 Female Wistar rats (8 wk old; 110-120 gm)

AREA OF STUDY: Nervous; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: The animals were restrained for 6 hr in a cylinder at a laboratory temperature of 18-19°C. After restraint, the rats were decapitated; brain cortex slices were prepared at 4°C from both brain hemispheres. Incubation with labeled leucine was for 30 min. Measurements: rectal temperature; corticosterone plasma levels; protein activity; oxygen consumption.

IMMOBILIZATION METHOD: Cylinder

RESULTS: Reduced voluntary muscular activity created a stress situation; rectal temperature decreased and the plasma level of corticosterone increased ($p < .001$). Oxygen consumption of brain cortical slices was about 31% higher ($p < .001$) than controls. Leucine uptake occurred against a high concentration gradient. Incorporation of [^{14}C]leucine was almost linear within the first 60 min of incubation; TCA-soluble fraction activity was about 23% higher ($p < .01$) than controls. Increased specific activity of proteins was not significant. Restraint stress in vivo altered the proteosynthetic capacity in vitro differently in individual-stressed rats.

SOURCE: Brain Research 23: 298-301, 1970

AUTHOR(S): Senay, E.C. and R.J. Levine

EXPERIMENT TITLE: Synergism Between Cold and Restraint for Rapid
Production of Stress Ulcers in Rats

SUBJECTS: Female CD rats (180-220 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: The animals were fasted 24 hr prior to restraint. Three groups:
1) restraint at room temperature for 2 hr - rats were placed in plastic
restraint boxes and glass test tubes were inserted to further immobilize the
animals; 2) restraint and placed in a cold room (4°-7°C) for 2 hr; 3) refri-
gerated at 4°-7°C without restraint for 2 hr. The animals were then
sacrificed, and the stomachs were removed and examined for lesions.

IMMOBILIZATION METHOD: Plastic cage, glass test tube

RESULTS: The combination of cold exposure and physical restraint yielded
a much greater incidence of lesions than did either type of stress acting
alone. Multiple severe lesions were found in 8% of animals subjected to
cold, 45% of those subjected to restraint and cold, and 0% subjected to
restraint alone.

SOURCE: Proceedings of the Society for Experimental Biology and Medicine
124: 1221-1223, 1967

AUTHOR(S): Serova, L.V.

EXPERIMENT TITLE: Change in Resistance of Animal Tissues During Prolonged Restriction of Motor Activity

SUBJECTS: 120 Adult male rats (250 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental rats were immobilized in cages for 60 days. Tissue resistance was determined from the uptake of neutral red dye by the diaphragm muscles.

IMMOBILIZATION METHOD: Cage

RESULTS: The decrease in overall body resistance during prolonged immobilization was accompanied by a change in tissue resistance. After 30-day immobilization, there was a 27% increase in dye uptake by the diaphragm muscle, indicating a decrease in the resistance of the muscle tissue. Uptake was inversely proportional to resistance. After 45 days, dye uptake was twice as great as controls. After 60 days, dye uptake was only 65% greater, indicating a normalization of tissue resistance.

SOURCE: Space Biology and Medicine 5(1): 122-124, 1971

AUTHOR(S): Sevastikoglou, J.A., R. Lemperg, S.E. Larsson, and S. Mattsson

EXPERIMENT TITLE: Chemical Composition of the Skeletal Parts of the Extremity of the Adult Rat Following Below-Knee Amputation and Immobilization in a Plaster Cast

SUBJECTS: Adult male Sprague-Dawley rats

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Two groups: 1) below-knee amputation of the right leg, 19 rats, for periods of 2-32 wk; 2) immobilization - 21 rats, right hind leg placed in plaster cast for 2-24 wk. Nonamputated and nonimmobilized legs served as controls. Both femurs and tibias were dissected free from soft tissue and periosteum, and acetonedried diaphyseal cortical bone powder was prepared. Measurements: ash, calcium, organic, hydroxyproline and hexosamine contents.

IMMOBILIZATION METHOD: Cast; Amputation

RESULTS: There were no significant differences in the chemical composition of the bones of the treated extremity as compared with the corresponding bones of the non-treated control leg. The percentage organic content prepared from the tibias and femurs of the amputated and the non-amputated leg showed significant differences between the corresponding bones of the two extremities and between the bones of the same extremity. The organic content of the amputated tibia was significantly higher than that of the tibia from the non-amputated leg. The percentage hydroxyproline content of the tibia was found to be significantly higher than that of the femur in both extremities, both in the amputation and immobilization experiments. The pro mille hexosamine content of the tibia was significantly lower than that of the femur in both extremities in the immobilization experiment.

SOURCE: Acta Chirurgica Scandinavica (Suppl. 467): 26-30, 1976

AUTHOR(S): Shakun, L.N.

EXPERIMENT TITLE: Effect of Syrepar and Oxaphenamide on Liver Function
in Experimental Hypokinesia

SUBJECTS: 207 Male rats (140-170 gm)

AREA OF STUDY: Digestive; Pharmacology

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) 30 days in restraint cages. All were injected daily with oxaphenamide or syrepar. Measurements: intensity of bile formation; concentration of cholic acids, bilirubin, and cholesterol in the bile; concentration of tauro- and glyco-conjugates in cholic acid.

IMMOBILIZATION METHOD: Cage (box)

RESULTS: Hypokinesia reduced the cholagogic action of oxaphenamide and increased bilirubin secretion. Under conditions of hypokinesia, syrepar moderately inhibited bile secretion but stimulated the release of bilirubin. In hypokinesia and controls, oxaphenamide and syrepar increased the cholate-cholesterol coefficient of bile.

SOURCE: Farmakologiya i Toksikologiya 41(4): 465-469, 1978

AUTHOR(S): Sharma, V.N. and F.S.K. Barar

EXPERIMENT TITLE: Restraint Stress As It Influences the Myocardium of Rat

SUBJECTS: 154 Albino rats (90-120 gm)

AREA OF STUDY: Circulatory; Endocrine

OBJECTIVES: In title

PROTOCOL: Six groups: 1) controls; 2) steroid-electrolyte conditioned; 3) 7-hr restraint; 4) steroid-electrolyte conditioned plus 7-hr restraint; 5) 18-hr restraint; 6) steroid-electrolyte conditioned plus 18-hr restraint. Restraint was maintained in a prone position by strips of adhesive tape applied to the rats' limbs and pinned to a wooden board. The rats were steroid-electrolyte conditioned by administration of 5 mg hydrocortisone sc once daily and 2 ml aqueous solution of 15% sodium acid phosphate orally twice daily for 4 days. Rats were killed by anesthetic ether inhalation following testing and hearts removed. Measurements: glycogen estimation, acetylcholine estimation; histological study.

IMMOBILIZATION METHOD: Wooden board and adhesive tape

RESULTS: The glycogen content in all the experimental groups was significantly reduced. The acetylcholine content followed no definite pattern. The main histological changes observed were round cell infiltration, myocardial edema, focal necrosis, vessel congestion and muscle fiber fragmentation. The highest percentage of abnormalities were found in group 6.

SOURCE: Indian Journal of Medical Research 54(12): 1102-1107, 1966

AUTHOR(S): Shashkov, V.S., B.S. Dmitriyev, A.I. Volozhin, B.B. Yegorov, V.I. Lobachik, A.I. Briskin, L.I. Stekol'nikov, D.D. Sumarovkov, V.N. Ivanov, K.K. Smirnov, and Ye.A. Artamasova

EXPERIMENT TITLE: Effect of Thyrocalcitonin on Water-Mineral Metabolism in Rabbits During Prolonged Restriction of Mobility

SUBJECTS: 40 Chinchilla rabbits (2500-2700 gm)

AREA OF STUDY: Fluid and Electrolyte; Blood

OBJECTIVES: In title

PROTOCOL: Hypokinesia: 30 days in cages. 4 groups: 1) control; 2) hypokinesia; 3) thyrocalcitonin (TCT); 4) hypokinesia and TCT. Groups 3 and 4 were administered TCT sc twice a day daily at the rate of 50 mg per injection. Urine collected on days 2, 7, 14 and 28 for groups 1 and 3; on days 2, 6, 8, 13, 15, 20, 22, 27 and 29 for groups 2 and 4. Several ml of blood taken from the marginal vein of the ear, to which heparin was added. Diet: standard briquetted food to which carrots, cabbage and hay were added; no restriction on water. Measurements: Na⁺, K⁺, Mg and Ca concentration in the urine and blood plasma.

IMMOBILIZATION METHOD: Cage

RESULTS: 30-day exposure to hypokinesia resulted in an increased excretion of calcium, sodium and water, a decreased excretion of magnesium and a variable pattern of potassium excretion with the urine. The blood concentration of potassium changed insignificantly and that of magnesium tended to increase. On the 23rd day of hypokinesia the animals exhibited a transient hyperkalemia and hypernatremia. Daily subcutaneous injections of thyrocalcitonin to hypokinetic rabbits led to a decreased urinary calcium excretion and normalization of magnesium excretion. Thyrocalcitonin did not aggravate shifts in the water, sodium and potassium excretion of hypokinetic rabbits and induced no significant changes in the plasma concentration of electrolytes.

SOURCE: Space Biology and Aerospace Medicine 8(3): 26-32, 1974

AUTHOR(S): Shashkov, V.S., V.P. Krotov, A.I. Volozhin, B.B. Egorov, and B.S. Dmitriev

EXPERIMENT TITLE: Effect of Prolonged Thyrocalcitonin Administration on Electrolyte Metabolism During Normal and Restricted Movement

SUBJECTS: 76 Male chinchilla rabbits

AREA OF STUDY: Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: Four groups: 1) control; 2) hypokinesia for 30 days in cages; 3) received thyrocalcitonin (TCT); and 4) hypokinesia plus TCT. 50 units TCT were injected sc into group 3 and 4 rabbits twice a day. Sodium, potassium, magnesium and calcium concentrations in the blood were determined before food intake on days 2, 8, 15, 22 and 30; electrolytes were determined in 24-hr urine and fecal specimens. Diet: standard pellet; hay; vegetables; water ad libitum. Measurements: sodium, potassium, calcium and magnesium excretion by the kidneys and gastrointestinal tract.

IMMOBILIZATION METHOD: Cage

RESULTS: Prolonged TCT administration to both control and hypokinetic rabbits caused: 1) an equal increase in the total potassium excretion; 2) a decrease in magnesium excretion and 3) no effect on sodium excretion. The total calcium loss from the body was much less for group 4 than for group 2.

SOURCE: Bulletin of Experimental Biology and Medicine 77(5): 491-493, 1974

AUTHOR(S): Shear, C.R.

EXPERIMENT TITLE: Cross-Sectional Myofibre and Myofibril Growth in Immobilized Developing Skeletal Muscle

SUBJECTS: Female white Leghorn chickens, 1 to 27 days old

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Three groups: 1) immobilization - one wing immobilized next to the body with a surgical adhesive cast, subjects sacrificed 1, 3, 6, 9, 12, 18, 21 and 27 days post-hatching; 2) immobilized-freed - animals with one wing immobilized for 3, 6, 9, 15, 18 and 24 days post-hatching were freed of casts for 72 hr, then sacrificed or animals immobilized for 2, 20 and 26 days post-hatching, freed of casts for 24 hr, then sacrificed; 3) non-immobilized - subjects were sacrificed 1, 3, 6, 9, 12, 18, 21 and 27 days post-hatching. Both the immobilized and nonimmobilized contralateral latissimus dorsi posterior muscles (PLD) were removed and prepared for electron microscopy. Diet: food and water ad libitum. Measurements: mean myofibre cross-sectional area; ultrastructural morphology.

IMMOBILIZATION METHOD: Cast

RESULTS: Immobilization immediately upon hatching resulted in a 25% decrease in mean myofibre cross-sectional area within 24 hr. Longer periods of immobilization further retarded normal myofibre growth until by day 27 after hatching the mean myofibre cross-sectional area was 70% less than normal. The variation in individual myofibre cross-sectional areas was greater in immobilized muscles. The larger immobilized myofibres showed atypical myofibril and sarcotubular complex organization at the ultrastructural level of observation whereas the smaller immobilized myofibres appeared normal except for their size. In 1 to 27-day old chicks, freeing the immobilized muscles for 24 hr resulted in myofibril reorganization and sarcotubular proliferation but little myofibre growth. Freeing the immobilized muscles for 72 hr resulted in a nearly complete recovery in chicks up to 18 days post-hatching, of both cross-sectional myofibre area and ultrastructural morphology. Myofibres immobilized for longer than 18 days and subsequently freed for 72 hr developed a normal myofibrillar and sarcotubular morphology but remained 23 to 29% smaller in cross-sectional area than myofibres from control muscles.

SOURCE: Journal of Cell Science 29: 297-312, 1978

AUTHOR(S): Shkurdoda, V.A.

EXPERIMENT TITLE: Effect of Brief Physical Training on the Survival of White Rats Kept Under Conditions of Prolonged Hypodynamia and Isolation

SUBJECTS: Male white rats

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Four groups: 1) controls; 2) hypodynamic in small cells, trained for 30 min daily on a vertical exercise pole; 3) hypodynamic, removed for 30 min daily to a spacious cage; 4) hypodynamic continuously. Groups 2, 3 and 4 were subjected to hypodynamia for 20 days. All 4 groups were x-irradiated with a dose of 750 R, including the controls. The survival of the animals was observed for 20 days. Measurements: indices of various motor and autonomic functions before and during hypodynamia, before irradiation and during radiation sickness.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: Of the animals given brief physical training, 6% died as compared with 41% of the untrained animals during hypodynamia. The most resistant group to irradiation were the animals given the brief physical training. Passive rest in a larger cage for 30 min daily improved survival rate but lowered resistance to radiation. 2-3 times more trained animals survived than untrained animals.

SOURCE: Aviation and Space Medicine (ed. by V.V. Parin), Washington, D.C., National Aeronautics and Space Administration, 1964, pp. 427-429. (NASA TT F-228)

AUTHOR(S): Shtykhno, Yu.M. and V.I. Udovichenko

EXPERIMENT TITLE: State of the Nutritive Circulation in Rats After Prolonged Hypokinesia

SUBJECTS: 40 Male Wistar rats (130-140 gm)

AREA OF STUDY: Circulatory; Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) rats placed in restrictive cages for 80-100 days. Measurements: at various times the microcirculation of the mesentery was studied and blood samples taken from the carotid and femoral arteries and the portal veins. The blood was analyzed for the indices of acid-base balance, hemoglobin concentration, hematocrit and degree of aggregation of the blood cells. Diet: pellets, carrots, cabbage, water ad libitum.

IMMOBILIZATION METHOD: Cage (restrictive)

RESULTS: Prolonged hypokinesia for 80-100 days caused a reduction of the network of true capillaries, emptying of the terminal arteries and arterioles, a change in direction of terminal blood flow in the arteriovenous anastomoses and a by-passing of the nutritive vessels. Buffer bases were low in the venous blood and a respiratory alkalosis was present in the arterial blood.

SOURCE: Bulletin of Experimental Biology and Medicine 83(4): 461-463, 1977

AUTHOR(S): Shtykhno, Yu.M. and V.I. Udovichenko

EXPERIMENT TITLE: Hemorheological Changes, The State of Microcirculation, And Blood Acid-Base Balance in Rats Under Conditions of a 30-Day Limiting of the Motor Activity

SUBJECTS: 26 Male Wistar rats (130-140 gm)

AREA OF STUDY: Circulatory; Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 13 control rats; 2) 13 hypokinetic rats held in small cages for 30 days. Measurements: indices of the acid-alkali balance in the carotid artery, and the femoral and portal veins; sedimentation rate of the erythrocytes; the hematocrit index; the aggregation index; the suspension stability of the blood; adhesion of the blood elements formed; and the dynamic fluidity.

IMMOBILIZATION METHOD: Cage

RESULTS: After 30 days hypokinesia, there was a reduction in the number of true capillaries, an appearance of nonfunctioning empty vessels; and an opening of the arteriolo-venula shunts. In terms of the rheological properties of the blood, there was an increase in dynamic viscosity, an increase of adhesion of blood elements formed, a reduction of suspension stability, and an increase in both the sedimentation rate of the erythrocytes and the hematocrit index. Changes in the acid-base balance in the direction of reduction of buffer blood content were noted.

SOURCE: Vestnik Akademii Meditsinskikh Nauk SSSR No.2: 68-71, 1978

AUTHOR(S): Shvets, V.N. and N.P. Krivenkova

EXPERIMENT TITLE: Hemopoietic Organs of Hypokinetic Mice

SUBJECTS: Female (CBA x C57BL)F1 mice (20-22 gm)

AREA OF STUDY: Blood; Circulatory

OBJECTIVES: To study the capacity of blood-forming cells for colony formation and the pattern of their differentiation during hypokinesia.

PROTOCOL: Two groups: 1) rats subjected to hypokinesia in cages; killed on 1st, 3rd, 7th, 15th, 30th and 45th day of the experiment; 2) controls. Measurements: body weight; weight and cell counts in thyroid, adrenals, spleen, inguinal lymph nodes, and bone marrow, number, size and structure of lymphocytes and granulocytes in peripheral blood; colony forming units (CFU) in spleen and bone marrow (cell devastation).

IMMOBILIZATION METHOD: Cage

RESULTS: In the hypokinetic mice there was an increase in the weight of the adrenals and atrophy of the thymic-lymphatic system, manifested in a decrease in weight of the thyroid, lymph nodes and spleen and a decrease in the number of cells containing nuclei. There were changes in the cellular composition of the peripheral blood in the form of lymphopenia, transient neutrophilic leukocytosis, a relative increase in the number of large lymphocytes, appearance of stress lymphocytes and a decrease in the absolute number of CFU in the spleen. The bone marrow was characterized by less clearly expressed changes in the total number of karyocytes and an increase in the number of CFU. The capacity of the blood-forming cells (in the spleen or bone marrow) for differentiation in the direction of erythro-, myelo- and thrombocytopoiesis remained unchanged in the case of restricted mobility.

SOURCE: Space Biology and Aerospace Medicine 10(3): 74-81, 1976

AUTHOR(S): Simard, C.P.

EXPERIMENT TITLE: Morphometric, Physiological, Histological, and Biochemical Changes in Rat Foot Extensors Immobilized By Plaster. Part I: Study of the Manifestation and Development of Muscular and Osseous Atrophy of the Immobilized Foot of the Rat

SUBJECTS: Wistar rats, 6 mo (300 gm)

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 3, 6, 10 and 17 day immobilization, 5 rats; 2) 4, 8, 12, 16, 20 and 24 day immobilization, 12 rats; 3) controls. Right leg and foot immobilized with plaster, foot put in a 90-95° dorsal flexion. Diet: food and water ad libitum. Measurements: muscle/bone weight; bone calcium level.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: There was very little difference between the weight of the immobilized or contralateral muscles in group 1; the ratio between the total weights of the atrophied extensors and the number of days of immobilization was 0.83. In group 2, the weight curve of all the extensors of the back limbs indicated an atrophization process progressing with the number of days, i.e., 10% after 4 days, 32% after 16 days and 44% after 24 days. The ratio between the total weights of the atrophied extensors and the number of days of immobilization was 0.98. The percentage of calcium loss corresponded to the percentage of muscular atrophy. There was progressive weight loss of the bone and its calcium level, which followed the curve of the immobilization period. The calcium level remained constant in comparison with the total weight of the bone itself.

SOURCE: Vie Medicale au Canada Francais 2: 325-340, 1973

AUTHOR(S): Simler, M., J. Schwartz, and J. Warter

EXPERIMENT TITLE: Effects of Restraint on Elimination of Uropepsin and the Urinary Steroids of Corticoadrenal Origin in the Rat

SUBJECTS: 60 White rats (150 gm)

AREA OF STUDY: Endocrine; Digestive

OBJECTIVES: In title

PROTOCOL: The rats were anesthetized with ether and placed in metal corselets for 24 hr, their front and rear feet bound. They received a 5 ml sc injection of physiological serum. Measurements: urinary excretion rates of 17-ketosteroids (17-KS), dehydroisoandrosterone (DHA), and uropepsin (during restraint and the periods before and after).

IMMOBILIZATION METHOD: Metal corselet

RESULTS: During restraint there was no change in 17-KS (average = 0.022 mg) and a lowering of DHA (0.005 mg) and uropepsin (9 units). The day following restraint there was a marked increase in 17-KS and a normalization of uropepsin.

SOURCE: Comptes Rendus des Sciences de la Societe de Biologie et de ses Filiales 156: 494-498, 1962

AUTHOR(S): Simonov, Ye.Y. and I.V. Fedorov

EXPERIMENT TITLE: Activity of Some Enzymes in the Blood Serum of Rats
During Prolonged Immobilization

SUBJECTS: 79 Albino male rats (150±20 gm)

AREA OF STUDY: Blood; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 40 control rats; 2) 39 experimental rats placed in small cages which restricted their mobility. Animals were killed after 1, 15 and 60 days of immobilization. Blood was collected and the serum was separated from the formed clot. Measurements: serum activity of glutamate-aspartate (GA), glutamate-alanin-aminotransferase (GAA), ketose-1-phosphate aldolase (KPA), lactate dehydrogenase (LDH), and nonspecific cholinesterase (NCE). Diet: no restrictions.

IMMOBILIZATION METHOD: Cage (small)

RESULTS: GA, GAA, KPA, LDH and NCE showed increased activity after 15 days. After 60 days, GA and GAA activity continued to increase while KPA, LDH and NCE decreased.

SOURCE: Space Biology and Medicine 4(1): 22-25, 1970

AUTHOR(S): Siryk, L.A.

EXPERIMENT TITLE: Effect of Development Under Conditions of Skeletal Muscle Loading and of Hypodynamia on Energy Metabolism in Rats

SUBJECTS: Male albino rats, 30 days or older (48-50 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Experimental period: 2 months. Three groups of 9 rats each: 1) controls; 2) "muscular" with gradually increased treadmill running from 20 min-120 min daily; 3) rats kept in chambers restricting motor activity. Animals were decapitated and a hind limb amputated and fixed in liquid nitrogen. Measurements: oxygen consumption; concentration of ATP, creatine phosphate, inorganic phosphorus, creatine, lactic, pyruvic acids, glycogen; body weight.

IMMOBILIZATION METHOD: Chamber (small)

RESULTS: Weight of the "muscular" rats was significantly higher due to an increase in the relative value of the total muscle mass. Oxygen consumption in the resting state was 17% lower in "muscular" animals and 62% higher in the hypodynamic animals in comparison to controls. A high concentration of ATP, creatine phosphate, and glycogen was found in the muscles of the muscular rats as well as a high glycogen concentration in the liver and a marked decrease in the lactate pyruvate ratio.

SOURCE: Bulletin of Experimental Biology and Medicine 74(10): 1244-1246, 1972

AUTHOR(S): Siryk, L.A.

EXPERIMENT TITLE: Some Biochemical Characteristics of Skeletal Muscles of Rats Developing Under Conditions of Increased Muscular Exertion and of Hypodynamia

SUBJECTS: Male albino rats (50-52 gm), 1 mo old

AREA OF STUDY: Muscular; Metabolism and Energy Exchange

OBJECTIVES: In Title

PROTOCOL: Four groups: 1) hypodynamia, temperature 20-22°C; 2) hypodynamia, temperature 28-30°C; 3) exercise, running on a flat treadmill for 10-60 min on alternate days; 4) controls, temperature 20-22°C. To create hypodynamia, the rats were kept in single cages with tightly constricting walls. After 60 days the animals were decapitated and the hind limb removed. Measurements: protein content, DNA, RNA, ATP, pyruvate, lactic acid and creatine phosphate in quadriceps femoris muscles; glycogen level in the muscles and liver; total lipid content; absolute and relative values of muscle mass; concentrations of protein, glucose, pyruvate and lactate in the blood.

IMMOBILIZATION METHOD: Cage

RESULTS: Exertion produced an increase in the mass of the skeletal muscles, and the muscles' protein, glycogen, ATP, and creatine phosphate content, and a decrease in their lactic acid content. Opposite changes were produced by hypodynamia and supplementary heating. Hypodynamia without heating caused no change in the energy and plastic resources of the body.

SOURCE: Bulletin of Experimental Biology and Medicine 81(3): 349-351, 1976

AUTHOR(S): Skuratova, S.A., V.S. Oganov, M.A. Shirvinskaya, and
V.S. Magedov

EXPERIMENT TITLE: Dynamics of Afferent Impulsation in Posterior Spinal
Radices of Dogs With Restricted Movement

SUBJECTS: 5 Dogs

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Immobilization: 30-40 days, locomotion precluded, only a change in position allowed. Bipolar electrodes were preimplanted in the posterior spinal radices. Measurements: spontaneous bioelectric activity of posterior spinal radices (through mean hourly values of the following parameters, which were averaged for every day separately: the value of effective voltage of overall impulsation within a specified time period, and averaged incidence of discharge over the same time period), and motor activity around the clock once a week.

IMMOBILIZATION METHOD: Not stated

RESULTS: First part of experimental period: 1) increase in motor activity in some animals; 2) tendency toward decline of mean effective voltage of biopotentials and increase in discharge frequency, or, absence of appreciable changes in the nature of afferent impulsation. Second part of experimental period (30th experimental day) - changes were in opposite direction: consistent increase in mean effective voltage of biopotentials, more marked decrease in mean frequency of discharges (so-called "synchronization effect"); decrease in motor activity. The general direction of changes in the parameters studied in a readaptation period was indicative of a tendency toward restoration of their base values.

SOURCE: Space Biology and Aerospace Medicine 12(4): 129-132, 1978

AUTHOR(S): Slack, H.G.B.

EXPERIMENT TITLE: Metabolism of Limb Atrophy in the Rat

SUBJECTS: Adult white albino rats (215-332 gm)

AREA OF STUDY: Metabolism and Energy Exchange; Muscular

OBJECTIVES: In title

PROTOCOL: Under ether anaesthesia, the right hind limb was denervated by avulsion of the anterior nerve trunks close to the spine. The hip joint was exposed by muscle splitting, the femoral head dislocated and the main joint ligaments severed. The skin of the limb was then stripped off, with the exception of the foot skin, and the limb implanted beneath the skin of the flank. The left hind limb served as a control. The rats were injected ip with methylene-labelled ^{14}C glycine (10 $\mu\text{C}/100\text{ gm}$). The animals were killed 1-15 wk after the operation. Three rats were usually used for each time period, 2 of the rats being given the glycine injection about 1 wk before killing and 1 injected soon after the operation. Measurements: the isotopic glycine content of liver protein, muscle protein, and collagen; body weight; limb weight.

IMMOBILIZATION METHOD: Denervation

RESULTS: Following denervation, the rats lost weight rapidly; being maximal on the 7th day post-operation. They then gained weight again at variable rates. The total wet weight loss of the operated limb was most rapid during the first 3 wk and thereafter tissue was lost at a slow but fairly steady rate (2%/wk). The rate of metabolism of muscle protein appeared to continue normally for at least 14 days after injection of the isotope, and as long as 14 days after the operation. There appeared to be a greater loss of the isotope from the atrophying muscle 10 wk after the injection and 15 wk after the operation. The specific activities of the whole collagen are on the average higher than those of the control limb. At 7 days post-operation, the content of isotopic glycine in liver protein was only 25% of that present at 24 hr.

SOURCE: Clinical Science 13: 155-163, 1954

AUTHOR(S): Smirnov, K.V., L.G. Goland, and I.L. Medkova

EXPERIMENT TITLE: Effect of Restricted Motor Activity on the Enzyme Secretion Function of the Pancreas and Extrasecretory Function of the Liver in Rats

SUBJECTS: Male rats (170-240 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) rats were placed in a small plexiglas cage for up to 15 days; 2) controls. The enzyme secretion function of the pancreas and the extrasecretory function of the liver (cannulation of the bile duct) were studied on day 3, 7 and 15 of hypokinesia and day 1, 3, 6, 12, 20 and 35 after release. Diet: briquetted food, sunflower oil. Measurements: pancreatic enzymes; amylolytic activity in tissue and blood; cholic acid, lipid complex and total phosphorus in the bile.

IMMOBILIZATION METHOD: Cage (plexiglas)

RESULTS: On the 3rd day of hypokinesia, there was a marked depression of amylolytic activity in the blood and tissue. The lipolytic activity in the blood and tissue increased, but a significant increase in lipase content was observed only in the gland tissue. Observations made on the 7th day showed a return of amylase and lipase activity in the blood and tissue to initial levels and absence of change in the proteolytic enzyme system. On day 15 of hypokinesia, there was a tendency to an increase in activity of the lipolytic and proteolytic systems, whereas amylase activity remained at the initial level. All bile components had increased by the 3rd day of hypokinesia, particularly the lipid complex; by the 7th day, cholic acid increased further but the lipid complex and total phosphorus decreased to control levels. By the 15th day, cholic acid decreased somewhat and liver complex and total phosphorus increased sharply. After release from immobilization, cholic acid increased on days 1, 6, 12 and 35, decreased on days 3 and 20. The lipid complex and total phosphorus was also phasic and higher than initial values.

SOURCE: Space Biology and Medicine 8(3): 33-40, 1974

AUTHOR(S): Smith, G.P., F.P. Brooks, R.A. Davis, and S.S. Rothman

EXPERIMENT TITLE: Fasting Gastric Contents in the Spider Monkey

SUBJECTS: Spider monkeys, 2 male, 3 female (2-3 kg)

AREA OF STUDY: Digestive

OBJECTIVES: To determine characteristics of fasting gastric contents of monkeys and changes with stimulation under restraint vs free-movement conditions

PROTOCOL: After an 18-hr fast, gastric contents were collected by dependent drainage with the animals restrained (3 hr) in a chair for 18 experiments and loose in their cages during 17 experiments. Histamine studies were performed by giving hourly sc injections of histamine acid phosphate for 4 hr. Insulin in approximately 2 U/kg dose was injected iv to produce hypoglycemia. Blood samples were drawn just prior to injection and again 1 hr later. Measurements: volume; free acid; total acid; pepsin concentration; sodium; potassium; chloride; acid output.

IMMOBILIZATION METHOD: Chair

RESULTS: There was a high acid concentration of the fasting gastric juice of all the monkeys. All monkeys tended to secrete a more acid juice when they were restrained. Sodium varied inversely with the hydrogen ion concentration, while the chloride concentration varied directly with that of the acid. There was no significant difference in acid output after doses of 0.4, 0.6 and 0.8 mg of histamine base. Pepsin production was enhanced by histamine. There was significant variation in the acid response in all the monkeys during the 4th and 5th hours following the insulin injection.

SOURCE: American Journal of Physiology 199(5): 889-892, 1960

AUTHOR(S): Smol'skiy, L.P.

EXPERIMENT TITLE: Hypokinesia and Macrometric Changes in the Seminal Vesicles

SUBJECTS: Sexually mature mice; rats

AREA OF STUDY: Reproductive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) experimental mice and rats were placed in plastic cages consisting of individual compartments for each animal. After 60 days of hypokinesia the animals were decapitated and the body, organ complex and seminal vesicle weight determined. Diet: standard.

IMMOBILIZATION METHOD: Cage (plastic)

RESULTS: Hypokinesia induced a significant decrease in the dimensions and absolute and relative weights of the seminal vesicles, along with a sharp reduction in the weight and length of the animals. The changes varied somewhat depending on the species and line of the animal.

SOURCE: Space Biology and Aerospace Medicine 9(6): 127-130, 1975

AUTHOR(S): Sneer, A., M. Dinu, V. Stroia, E. Constantin, and I. Nitulescu

EXPERIMENT TITLE: Contribution to the Study of the Action of the Adrenocortical Glands on the Production of Gastric Ulcerations in the Rat by Prolonged Immobility

SUBJECTS: 89 Male white rats (aver. 160 gm)

AREA OF STUDY: Digestive; Endocrine

OBJECTIVES: In title

PROTOCOL: Four groups: 1) normal animals (part fasted); 2) animals subjected to immobilization (fixation on table) for 24 hr; 3) animals injected with 5 mg/100 gm body weight of cortisone 1 day before and during immobilization, at a 12-hr interval; 4) animals subjected to immobilization 7 days after bilateral adrenalectomy. Animals deprived of food 17-18 hr prior to and during immobilization. Immediately after fixation on the table the animal was injected sc with 5 ml of isotonic solution of sodium chloride. Measurements: body weight; mortality; ulceration incidence; uropepsin, 17-ketosteroids and 17-hydroxycorticosteroids in urine.

IMMOBILIZATION METHOD: Fixation on table

RESULTS: Weight reduction was more pronounced in animals in which immobilization was associated with cortisone. The mortality rate was 11% for animals subjected to simple immobilization and 44% in those which had been adrenalectomized first. Immobilization combined with cortisone permitted survival of all animals. Ulcerating lesions did not appear in group 1, but appeared in 78% of animals subjected to simple immobilization; dropped to 44% in the animals adrenalectomized first, and rose to 100% in immobilized animals injected with cortisone. Immobilized animals showed a reduced elimination of uropepsin and 17-hydroxycorticosteroids and an increased elimination of 17-ketosteroids.

SOURCE: Fiziologia Normala si Patologica 15: 307-315, 1969

AUTHOR(S): Sneer, A., M. Dinu, V. Stroia, and E. Constantin

EXPERIMENT TITLE: Study of Electrocardiographic Alterations Induced By Forced Immobilization of Rats Against a Background of Experimental Hypo and Hyperthyroidism

SUBJECTS: 88 Male Wistar rats (140-160 gm)

AREA OF STUDY: Circulatory; Endocrine

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls, subjected to immobilization; 2) immobilization against a background of hypothyroidism induced by an ip injection of 0.5% solution of methylthiouracil (MTU) for 21 days or thyroidectomy performed 7 days prior to immobilization; and 3) immobilization against a background of hyperthyroidism induced through im injection of 50 γ /100 gm/day) thyroxine for 14 days. Before and 7, 10 and 20 days after the thyroidectomy or after the administration of thyroxine or MTU, EKGs were recorded for all animals during immobilization for 4 and 24 hr. On the 6th day after immobilization sodium and potassium in their urine was measured. The state of thyroid hypo- or hyperfunction was established through determination of the basal metabolism.

IMMOBILIZATION METHOD: Fixation on table

RESULTS: EKGs in controls, normal prior to restraint, showed over-dislevelment of the ST segment in bipolar lead III after 4 hr and a bradycardia that intensified after 24 hr as well as intraventricular conduction disorders. Group 2 rats showed a drop in cardiac frequency 7 days postthyroidectomy or 21 days after MTU. Restraint accentuated the bradycardia of all thyroidectomized rats and only 60% of those treated with MTU; the rest showed tachycardia or an unaltered EKG. In group 3 rats, cardiac frequency increased 10 days after thyroxine and a potential drop especially in bipolar lead II was noted. Forced restraint in 67% of the rats caused an even greater increase in cardiac frequency. In 25% of the rats, the EKG following restraint showed a bradycardiac rhythm and a T-wave of increased amplitude. All groups showed increased elimination of potassium during 24-hr restraint, but it was most evident in simple restraint. Sodium elimination showed no significant alterations.

SOURCE: Revista Medico-Chirurgicala a Societatii di Medici si Naturalisti din Iasi 74: 433-440, 1970

AUTHOR(S): Sneer, A., V. Colev, E. Dughir, and I. Sneer

EXPERIMENT TITLE: Influence of Circadian Rhythm on the Production of Gastric Ulcer Due to the Stress of Forced Immobilization

SUBJECTS: Adult male Wistar rats

AREA OF STUDY: Digestive; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) immobilization started in the morning; 2) immobilization started in the evening. The rats were killed. Measurements: urinary 17-OH, 17-KS and uropepsin; glycemia; hepatic glycogen; proportion of animals with ulcerations; proportion of damaged tissue area; mortality.

IMMOBILIZATION METHOD: Not stated

RESULTS: The disturbances were more marked following restraint applied in the evening. The proportion of rabbits with ulcerations after evening immobilization was 90% compared to 62% after morning immobilization; the ulcerated surface being 9.2 mm² compared to 4.8 mm². Glycemia and hepatic glycogen presented higher values in the animals immobilized in the morning. Urinary 17-OH, 17-KS and uropepsin elimination was higher in the evening group.

SOURCE: Revista Medico-Chirurgicala a Societatii de Medici si Naturalisti din Iasi 80(3): 419-424, 1976

AUTHOR(S): Sobocińska, J.

EXPERIMENT TITLE: The Effect of Immobilization on Body Fluid Volume in the Rat

SUBJECTS: 48 Male albino rats

AREA OF STUDY: Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 24 controls; 2) 24 rats immobilized for 2, 4 and 8 wk. All rats were injected ip with 50 μC of ^3H to determine total body water, and 5 μC of ^{82}Br in the form of NH_4Br to determine extracellular fluid.

IMMOBILIZATION METHOD: Not stated

RESULTS: No changes in total body water and extracellular fluid were found after 2, 4, and 8 wk immobilization.

SOURCE: Space Life Sciences 4: 307-308, 1973

AUTHOR(S): Sobocińska, J.

EXPERIMENT TITLE: The Effect of Prolonged Immobilization on Diuresis and Water Intake in Rats

SUBJECTS: 50 Male albino rats

AREA OF STUDY: Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 20 controls; 2) 20 rats immobilized for 8 wk in cages; 3) 10 rats immobilized for 4 wk. Measurements: water intake; urine volume; Na and K concentration in urine.

IMMOBILIZATION METHOD: Cage

RESULTS: Within the first few days of immobilization urine excretion increased progressively and within 4 wk stabilized on a much higher level as compared to the controls and to the pre-immobilization values of the same rats. Water intake also increased. Neither changes in sodium and potassium excretion nor in Na/K ratio were observed during the immobilization period.

SOURCE: Space Life Sciences 4: 200-203, 1973

AUTHOR(S): Sohar, I., O. Takacs, and F. Guba

EXPERIMENT TITLE: The Influence of Immobilization on Soluble Proteins of Muscle

SUBJECTS: Male and female New Zealand rabbits (3000 gm)

AREA OF STUDY: Muscular; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: The right hind legs were immobilized in extension (groups of 10 rabbits) for 7, 14, 28 or 42 days. The gastrocnemius and m. soleus muscles were excised. Measurements: activities or relative amounts of the following soluble proteins: lactic acid dehydrogenase, glutamic acid-pyruvic acid transaminase, acid phosphatase, and fructose-1.6 diphosphate aldolase.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: The quantities of the enzymes playing important roles in the metabolic processes fell as a result of disuse to a relatively greater extent than the weight decrease. The quantity of acid phosphatase in m. gastrocnemius did not change during atrophy but decreased in m. soleus compared to the muscle weight loss. The activities of LDH-1 and LDH-2 decreased considerably whereas LDH-4 and LDH-5 hardly changed.

SOURCE: Acta Biologica et Medica Germanica 36: 1621-1624, 1977

AUTHOR(S): Sokolov, N.Ye.

EXPERIMENT TITLE: The Effect of Hypodynamia and Hypokinesia on the Arterial Tree of the Pelvic Muscles of the Rabbit's Extremities

SUBJECTS: 29 Rabbits

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control, 8 rabbits; 2) experimental - the right pelvic extremity was immobilized in a flexure position using a circular plaster cast from 1 wk to 6 mo, 21 rabbits. At various times, the arterial tree of the pelvic muscles of the extremities was studied by injecting a contrast medium into the arteries of the animal and x-raying the area under study. After this procedure the vessels were injected with latex, removed, and studied using light microscopy.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: Hypodynamia caused certain morphological changes in the arterial tree of the muscles of the immobilized extremity and in the formations surrounding the muscles. These changes were manifested in expansion of the arteries, an uneven diameter along their course and extrusion of the injection mass beyond the limits of the blood vessel into the surrounding tissue.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 67(4): 48-52, 1972

AUTHOR(S): Sokolova, Z.A.

EXPERIMENT TITLE: The Dynamics of Certain Indicators of Nucleic Metabolism During Hypokinesia in Rats of Different Ages Under the Influence of Sinusoidal Modulated Currents and Measured Physical Load

SUBJECTS: 100 Male Wistar rats (50-180 gm)

AREA OF STUDY: Muscular: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls for 2 age groups; 2) age 25-30 days; 3) age 55-60 days. Hypokinesia was produced in the group 2 and 3 rats for 30 days by placement in an individual cage which limited their movement. In each group, some rats received the influence of sinusoidal modulated currents (SMC) for 20 min twice daily during immobilization and some received a measured physical load (treadmill for 2 min daily). Measurements: the nucleic acid content of the hind leg skeletal muscles was determined spectrophotometrically and the total RNA content by ion-exchange chromatography.

IMMOBILIZATION METHOD: Cage

RESULTS: Hypokinesia for 30 days in rats aged 1 and 2 mo led to a reduction in RNA content and to a change in the relation of nucleotides in the total RNA of the muscle tissue. The application of SMC to these rats during the period of immobilization retarded the reduction of RNA level in the muscles. With the influence of SMC with frequency modulation of 30 Hz, the specificity coefficient of muscle tissue RNA was reduced, while it remained unchanged at a frequency modulation of 100 Hz. Measured physical load applied to the hypokineticized animals had no significant effect on the content of nucleic acids and the nucleotide composition of total RNA in the skeletal muscles.

SOURCE: Voprosy Kurortologii, Fizioterapii i Lechebnoi Fizicheskoi Kultury No. 5: 67-70, 1977

AUTHOR(S): Sokolova, Z.A.

EXPERIMENT TITLE: The Influence of Modulated Sinusoidal Current on the State of Chromatin From Neurons of the Cerebral Cortex of Rats in Hypokinesia

SUBJECTS: 50 Male Wistar rats (160-200 gm)

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Five groups of 10 animals each: 1) intact; 2) hypokinesia for 30 days; 3) subjected to measured physical stress on a treadmill for 20 min daily for 20 days; 4) subjected to modulated sinusoidal current (MSC) during immobilization for 20 min twice daily for 20 days; 5) subjected to measured physical strain during hypokinesia. Hypokinesia was obtained by placing rats in individual cages. Rats were killed and chromatin from the nuclei of cerebral cortex cells was examined. Measurements: intensity of the fluorescence of the complex of acridine orange and DNA chromatin, giving an idea of the degree to which the DNA chromatin molecule is blocked by proteins, and consequently, the degree of its matrix activity.

IMMOBILIZATION METHOD: Cage

RESULTS: Simultaneous examination of large pyramidal and stellate neurons permitted a comparative analysis of the intensity of fluorescence in the nuclei of these cells. In the intact (control) rats, the intensity of fluorescence in the large pyramidal neurons was almost twice that of stellate neurons, and consequently pyramidal neurons were in a more active state. Hypokinesia significantly decreased fluorescence equally in both pyramidal and stellate neurons, whereas physical stress did not effect the intensity of fluorescence. Under the influence of hypokinesia and MSC, significant changes took place only in the large pyramidal neurons, which increased in activity. Hypokinesia plus physical stress did not incur significant changes of intensity of fluorescence in either pyramidal or stellate neurons of the cerebral cortex.

SOURCE: Voprosy Kurortologii, Fizioterapii i Lechebnoi Fizicheskoi Kultury No.1: 56-59, 1978

AUTHOR(S): Solandt, D.Y. and J.W. Magladery

EXPERIMENT TITLE: The Relation of Atrophy to Fibrillation in Denervated Muscle

SUBJECTS: Albino rats (200-300 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Denervation was accomplished in the gastrocnemius-soleus group of muscles by removing a length of the sciatic nerve (approx. 0.5 cm) high in the thigh. Measurements: weight of denervated and normal muscles; weight of fibrillation-arrested denervated muscles; fibrillation (electrical method). Diet: adequate. Quinine and quinidine (50-100 mg/kilo in 25% aqueous solution) were utilized to arrest fibrillation.

IMMOBILIZATION METHOD: Denervation

RESULTS: Motor denervation produced both a progressive weight loss and fibrillation. 14 days after denervation the weight of denervated muscle was reduced to about half that of normal control. Denervated muscle still atrophied markedly after prevention of fibrillation by use of quinidine.

SOURCE: Brain 63: 255-263, 1940

AUTHOR(S): Solandt, D.Y., R.C. Partridge, and J. Hunter

EXPERIMENT TITLE: The Effect of Skeletal Fixation on Skeletal Muscle

SUBJECTS: Rats (175-250 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Animals were under light ether anesthesia during all operative and experimental procedures. The knee and ankle joints of one limb (different sides in alternate animals) were fixed with steel pins. Muscles were tested for fibrillation by the electrical method and .5 cc aqueous acetylcholine bromide solution was injected intraarterially into the exposed abdominal aorta or into each iliac artery. In most experiments, motor nerves to the muscles were cut just prior to the acetylcholine sensitivity testing. Measurements: gastrocnemius-soleus muscle groups; acetylcholine sensitivity, weight.

IMMOBILIZATION METHOD: Steel pins

RESULTS: Skeletal atrophy and hypersensitivity to acetylcholine occurred. Atrophy was marked during the first 10 days. After 10-14 days, atrophy stabilized; gastrocnemius muscles atrophied 50-60% of the weight of the control muscles at 10-14 days. No fibrillation occurred at any time. There was a marked increase in sensitivity to acetylcholine reaching a maximum about 10 days, which tended to return to normal although atrophy was maintained.

SOURCE: Journal of Neurophysiology 6: 17-22, 1943

AUTHOR(S): Song, T.S. and H.S. Kwun

EXPERIMENT TITLE: Influence of Stress on the Juxtaglomerular Cell of Mice

SUBJECTS: Male mice, D.D.O./Lee (20 gm)

AREA OF STUDY: Urinary

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls; 2) pain-stressed by injecting mice with 10% formaline; 3) immobilized by binding both extremities on a rat board for 12 hr daily. Animals were sacrificed 1, 2, 3, 6, 12 hr and 1, 2, 4, 6 and 10 days after 3 stresses. Measurements: granulation cell index (GCI); juxtaglomerular granulation index (JGI); morphological changes of cells

IMMOBILIZATION METHOD: Board

RESULTS: The GCI of the juxtaglomerular cells of the controls was 27.0 and its JGI was 33.0. The JGI of pain-stressed animals rose rapidly but returned to its normal value at the 2nd or 4th day. Changes of the GCI and JGI of the restraint-stressed animals were less but of the same tendency as those of the pain-stressed animals. The increase of the JGI was not dependent upon the increase of the juxtaglomerular cells, but upon the increase of the granularity of the cells. The thickness of the adrenal cortex increased but width of the zona glomerulosa was decreased.

SOURCE: Journal of the Catholic Medical College 19: 171-181, 1970

AUTHOR(S): Sood, S.C.

EXPERIMENT TITLE: A Study of the Effects of Experimental Immobilization
on Rabbit Articular Cartilage

SUBJECTS: 29 Adult male rabbits (5-12 mo old)

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Three groups: 1) control joints - 6 rabbits; 2) immobilized joints - in 12 rabbits the knee of one hind limb was placed in a plaster cast for 1-16 wk; 3) remobilized joints - in 11 rabbits the left knee was immobilized for 7-14 wk, the cast then removed, both knee joints removed and examined after 7-14 wk or more. Measurements: articular cartilage; cartilage thickness, nuclear counts, matrix histochemistry; reversibility.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: There was less cartilage thickness in the 12 immobilized joints; the matrix showed diminished staining reactions in its ground substance. Nuclear counts were higher in immobilized joints when compared with contralateral joint in the same animal and in controls. In remobilized rabbits, there was a diminution in the staining reaction of the matrix; reversibility of this condition occurred if remobilization was sufficiently prolonged.

SOURCE: Journal of Anatomy 108(3): 497-507, 1971

AUTHOR(S): Squires, R.D., F.H. Jacobson, and G.E. Bergey

EXPERIMENT TITLE: Hypothermia in Cats During Physical Restraint

SUBJECTS: 103 Cats

AREA OF STUDY: Nervous; Metabolism

OBJECTIVES: In title

PROTOCOL: Two groups: 1) restrained in the metabolic chamber at an ordinary temperature (22°C) for 23 mo; 2) restrained in a cold environment (10°C) for 23 mo. Measurements: core temperature, and temperature of the preoptic region of the brain and the hypothalamus was measured by bead thermistors surgically implanted under pentobarbital sodium anesthesia 2 wk before restraint.

IMMOBILIZATION METHOD: Not stated

RESULTS: The hypothermia which sometimes occurred in cats during physical restraint was on the average accompanied by decreased heat production and by increased heat loss. These changes were facultative rather than obligatory correlates of physical restraint and/or the unfamiliar surroundings in which the restraint took place. The decreased heat production was due to a temporary attenuation or loss of the increase in oxygen consumption rate which followed a decrease in medial preoptic and anterior hypothalamic temperature, and the increased heat loss appeared to be largely due to temporary hyperventilation.

SOURCE: Naval Air Development Center, Warminster, Pennsylvania, October 29, 1971, 25 pp. (NADC-CS-7117)

AUTHOR(S): Stanishevskaya, A.V. and L.N. Mezentseva

EXPERIMENT TITLE: Effect of Certain Psychopharmacological Preparations on Adaptation Under Stress Conditions

SUBJECTS: Male rats (220-250 gm)

AREA OF STUDY: Pharmacology; Endocrine

OBJECTIVES: In title

PROTOCOL: Three groups: 1) subjected to immobilization and decapitated in 24 or 48 hr; 2) injected with one of the following 30 min before immobilization: seduxen 5 mg/kg, inderal .5 and 2 mg/kg, phenamine 5, 10 mg/kg, phentolamine, 5 mg/kg, pyroxan 20 mg/kg and l-dopa 50 mg/kg; 3) controls. The stress state was produced by a 3 hr immobilization with simultaneous electrical stimulation. Measurements: stomach ulceration, adrenal gland weight and histochemical determination of norepinephrine and epinephrine, and catecholamines in the mesencephalon and hypothalamus were determined fluorometrically.

IMMOBILIZATION METHOD: Not stated

RESULTS: Development of ulcerative lesions of the gastric mucosa were associated with the degree of drop in the catecholamines level in mesencephalon and hypothalamus. The application of seduxen and of combinations of l-dopa with seduxen, or with an l-adrenoblocking agent such as pyroxan reduced the frequency of ulcerative lesions of the stomach. The protective effect of the combination of l-dopa and pyroxan was barred by the administration of the β -adrenoblocking agent inderal.

SOURCE: Farmakologiya i Toksikologiya 40(1): 9-12, 1977

AUTHOR(S): Steinman, R.R., M. Brussett, and P. Tartaryn

EXPERIMENT TITLE: Comparison of Caries Incidence in Exercised and Immobilized Rats

SUBJECTS: Osborn-Mendel rats

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Rats were weaned at 21 days of age and placed on a cariogenic diet. Two groups: 1) placed in a large cage and exercised 4 hr daily in a rotating cage; 2) restricted in wire cage. All animals were sacrificed at 29 days of age and the jaws frozen and sectioned. Measurements: incipient lesions in the dentin.

IMMOBILIZATION METHOD: Wire cage

RESULTS: Immobilized animals had a total of 192 lesions (14 per animal), exercised animals a total of 61 (4.3 per animal).

SOURCE: Journal of Dental Research 40: 218, 1961

AUTHOR(S): Strandh, J., A. Bengtsson, H. Semb, and K. Solheim

EXPERIMENT TITLE: The Effect of Immobilization on the Rate of Uptake of Phosphorus in Microscopic Bone Structures

SUBJECTS: 6 Harrier dogs (8-160 days old)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: The left foreleg of each animal was immobilized in plaster of Paris extending from the middle of the humerus to the distal part of the extremity over the paw, with 90° of flexion at the elbow and 80-90° of plantar flexion at the radiocarpal joint. Duration: 11 and 42 days. One or 4 days prior to cast removal, every dog was given 0.6-1.2 mC P^{32} /kg iv; bones were resected immediately postrestraint. Measurements: phosphorus activity.

IMMOBILIZATION METHOD: Plaster of Paris cast

RESULTS: Uptake was significantly decreased in the periosteal and endosteal lamellar bone closest to the periost and endost, respectively, compared with the control leg. This difference was not found in highly mineralized Haversian systems or in the endosteal lamellar bone closest to the Haversian systems.

SOURCE: Acta Societatis Medicorum Upsaliensis 69(5/6): 233-240, 1964

AUTHOR(S): Strelkovs'ka, V.Ye.

EXPERIMENT TITLE: State of the Mitral Valve in Rabbits with Hypokinesia

SUBJECTS: 26 Sexually mature rabbits

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 6 controls; 2) 20 hypokinetic. Hypokinesia was induced in rabbits by placing them in narrow cages. After 1, 2, 4 and 7 months, the animals were killed. The state of the mitral valve was studied.

IMMOBILIZATION METHOD: Cage

RESULTS: The animals lost weight from constant long term study. The absolute weight of the heart decreased from normal (6-8.1 gm in the hypokinetic animals and 7.1-8.5 gm in the controls). The relative weight of the heart did not undergo particular changes (0.34 in the hypokinetic and 0.43 in the controls). Under hypokinesia cytoarchitectonics of the mitral valve underwent considerable changes which progressed depending on the increase in duration of the experiment. Edema of the valve tissue appeared first, and this led to dystrophic and destructive changes in the cell elements of the fibers of the valve layers. Here, the proportion between the fibrous structures of the connective tissue and the number of cell elements was disrupted. The latter generally were rarely found, and the collagen fibers became numerous, thick and had altered staining properties. The number of elastic fibers decreased.

SOURCE: Dopovidi Akademii Nauk Ukrainskoi RSR. Seriya B. Heolohichni, Khimichni Ta Biolohichni Nauky 36(1): 72-75, 1974

AUTHOR(S): Stroganova, Ye.A.

EXPERIMENT TITLE: Effect of Prolonged Hypodynamia on Rat Biology

SUBJECTS: 36 White rats (135-145 gm)

AREA OF STUDY: Reproductive

OBJECTIVES: To investigate the effects of hypodynamia on the sexual behavior of rats and on the growth and development of their offspring.

PROTOCOL: Two groups: 1) controls; 2) 10 male and 10 female rats were kept in small-volume chambers, plastic pens for 62 days. At the end of hypodynamia, control and experimental rats were placed in cages for mating (1 male and 1 female per cage). Measurements: body weight of rats; body weight and torso and chest girth of offspring.

IMMOBILIZATION METHOD: Chamber (small plastic pen)

RESULTS: During hypodynamia, the test animals lagged greatly behind the controls in their weight gain. Following exposure to hypodynamia the test animals changed their sexual behavior. Experimental female rats showed more sexual desire than their control counterparts. The offspring of the experimental group grew and developed slower than their control counterparts, the difference leveling off in a month and later.

SOURCE: Space Biology and Medicine 6(6): 59-67, 1972

AUTHOR(S): Stroganova, Ye.A. and A.I. Volozhin

EXPERIMENT TITLE: State of Skeletal Bones in Ratlets Born from Females
Exposed to Prolonged Hypodynamia

SUBJECTS: 34 Sexually mature common rats (17 male, 17 female)

AREA OF STUDY: Reproductive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 9 male and 9 female (controls); 2) 8 male and 8 female rats placed in special individual plastic confining cages for 60 days. Postrestraint: rats were mated. Ca^{45} was injected into offspring on days 20, 30, 40, 60 and 120 after birth. 24 hr later, ratlets were decapitated, molars, lower jaws, and hip and tibial bones were removed and reduced to ash. Measurements: offsprings' weight; torso length; chest girth; hair cover appearance; eye opening.

IMMOBILIZATION METHOD: Cage (plastic)

RESULTS: Rats exposed to 60 day hypodynamia gave birth later and in smaller numbers. The offsprings' eye opening and hair covering developed later than controls. During the first 30-40 days, ratlets' weight and size lagged behind controls; at later stages, the differences between the 2 groups disappeared. Test ratlets showed a higher degree of mineralization and Ca^{45} incorporation in bone and tooth tissues.

SOURCE: Space Biology and Medicine 7(5): 39-44, 1973

AUTHOR(S): Sullivan, M.

EXPERIMENT TITLE: Effect of Chronic Restraint on Gastrointestinal Function

SUBJECTS: Male Charles River strain CD rats

AREA OF STUDY: Digestive; Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: Chronic restraint: 5 series of experiments. 1) Influence of chronic restraint on rat weight: 10 wk, 23 rats, diet - food/water ad libitum. 2) Influence of chronic restraint on fluid and electrolyte insorption by the small intestine, in situ: a) 6 rats, 3-4 wk restraint, unidirectional pumping of physiological buffer (pulse labeled with ^{22}Na , ^{36}Cl , ^{45}Ca , ^3HOH , and polyethylene glycol); b) glucose-free perfusate labeled with ^{22}Na and ^3HOH passed through intestine for 2 hr; c) acute restraint: second stress - 2 day fast - superimposed upon and followed by severe restraint: 5-7 wk, 12 rats, similar perfusion as before. 3) Effects of chronic restraint on the bioelectric and transport properties of specific regions of the small intestine: 2 wk, 5 rats, subjects fasted 1 day and fed 2 hr before voltage measurements. 4) Influence of chronic restraint on ^{45}Ca absorption and retention by non-anesthetized rats: a) 6 rats, 6 wk restraint, killed 24 hr after administration of ^{45}Ca in 1-ml buffer by gavage; b) 12 rats, 12 wk restraint, subjects held for 1 wk after administration of ^{45}Ca , 6 by gavage, 6 by intraperitoneal injection. 5) Combined effects of restraint and x-rays: 15 rats, 2-3 wk restraint, administered 600 R abdominal x-irradiation (after 1-day fast), then sacrificed 3 days later. Measurements: body weight; fluid and electrolyte insorption; voltage measurements; femoral radioactivity; femur ash weight; bioelectric potentials and ^{22}Na , ^{36}Cl , and ^3HOH transport.

IMMOBILIZATION METHOD: Cage (restraint)

RESULTS: Series 1) Restraint caused a significant depression in the growth of rats. Series 2a) Chronic restraint had little effect on insorption; ^{22}Na , ^{36}Cl , and ^3HOH insorption were depressed by eliminating glucose from the perfusate, but this effect was similar for both restrained/controls; ^{45}Ca insorption was usually less than 10%, variable, and not significantly altered by restraint; b) no serious influence on the state of absorption; c) results obtained for restrained and control rats were comparable and similar to 2a. Series 3) No significant effect on the bioelectric potential measurements from chronic restraint. Series 4) ^{45}Ca retention by restrained rats was slightly lower following gavage administration, although effect was neither large nor significant; ^{45}Ca retention by restrained rats was the same following intraperitoneal administration for the restrained/controls; 12 wk restraint caused a significant depression in both body and femur ash weight. Series 5) Neither chronic restraint nor prior 600 R abdominal x-irradiation had a significant effect on the bioelectric potentials of transport measurements for ^3HOH , ^{22}Na , and ^{36}Cl .

SOURCE: Pacific Northwest Labs., Battelle Memorial Institute, Richland, Washington, March 1967, 26 pp. (NASA-CR-73071)

AUTHOR(S): Summers, T.B. and H.M. Hines

EXPERIMENT TITLE: Effect of Immobilization in Various Positions Upon the Weight and Strength of Skeletal Muscle

SUBJECTS: 59 Adult cats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Immobilization: 14, 28 and 42 days. A contoured cast made from crinoline cloth impregnated with plaster was fitted to the experimental limb from midthigh to midtarsal region. Gastrocnemius and soleus muscles were tested under 1) neutral or resting, 2) stretched, and 3) shortened conditions. Measurements: muscle weight; muscle strength.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: All 3 positions resulted in atrophy and loss of strength with atrophy the greatest in the shortened position and least in the stretched position. Hypertrophy in the stretched solei was seen at 14 days and atrophy after 28 days. Immobilization in the neutral or resting position was the least deleterious.

SOURCE: Archives of Physical Medicine 32: 142-145, 1951

AUTHOR(S): Suzuki, T., R. Higashi, H. Tanigawa, H. Ikeda, and K. Tamura

EXPERIMENT TITLE: Adrenal Cortical Response to Immobilization in Conscious and Anesthetized Dogs

SUBJECTS: 14 Mongrel dogs (11-18 kg)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 9 conscious dogs; 2) 5 anesthetized (sodium pentobarbital). Adrenal venous blood was collected 30 and 10 min before immobilization. The animals were immobilized for 60 min by strapping them supine or prone to the animal table with a metallic head holder and cotton strings for the limbs. Adrenal venous blood was collected at 20, 40 and 60 min during restraint and at 15, 30, 60, 90 and 120 min post-restraint. Measurement: 17-hydroxycorticosteroid (17-OHCS).

IMMOBILIZATION METHOD: Metallic head holder, cotton strings, and table

RESULTS: Conscious dogs: 17-OHCS secretion rates increased markedly during restraint (from 0.02-0.21 mg/kg/min to 0.81-1.80 mg/kg/min). Anesthetized dogs: no definite change in 17-OHCS during or after restraint.

SOURCE: Tohoku Journal of Experimental Medicine 94: 281-285, 1968

AUTHOR(S): Sviridkina, L.P.

EXPERIMENT TITLE: The Effect of Hypokinesis on Blood Clotting in Rabbits

SUBJECTS: Male chinchilla rabbits (2-3 kg)

AREA OF STUDY: Blood; Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 40 rabbits kept hypokinetic in wire net cages for 14 days; 2) 13 control rabbits. Blood was collected from the ear marginal vein. Measurements: whole blood clotting time, plasma recalcification time, prothrombin uptake, plasma tolerance to heparin, prothrombin time, thrombin time, free heparin time, fibrinogen and fibrinogen B levels, plasma fibrinase activity, plasma antiheparin activity, fibrinolytic activity of whole blood and blood clot density, thrombocyte count adhesivity, thrombocytic spreading and aggregation activity, the monomers of fibrin, arterial pressure and EKG.

IMMOBILIZATION METHOD: Cage (wire netting with adjustable height)

RESULTS: After 14 days of hypokinesia, whole blood coagulation time decreased 26%, and plasma tolerance to heparin increased 31%. Recalcification time decreased 16.8% with an increase of 15% in prothrombin uptake in plasma with a normal thrombocyte count. The activity of antiheparin agents rose 2.2 times during the experiment and the prothrombin time decreased by 12%. Thrombin time decreased 15% and free heparin time by 2.7 times in plasma containing thrombocytes. Fibrin stabilizing factor activity increased 8%. Hypercoagulability also increased in plasma devoid of blood platelets. The level of fibrinogen B was elevated by 21 times. There was a 34% inhibition of fibrinolysis and 1.5 times increase in clot density. The thrombocytic coagulative activity decreased despite an increased content by 33%. The thrombocytic functional activity increased; thrombocytic spreading capacity doubled and the adhesivity index increased 1.8 times. The arterial pressure tended to elevate; myocardial ischemia lesions were demonstrated.

SOURCE: Cor et Vasa 20(5/6): 392-399, 1978

AUTHOR(S): Sviridkina, L.P.

EXPERIMENT TITLE: State of Blood Clotting During Prolonged Hypokinesia

SUBJECTS: 66 Male chinchilla rabbits (2-3 kg)

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 40 control rabbits; 2) 13 hypokinetic for 14 days; 3) 13 hypokinetic for 30 days. Hypokinesia was created by placing the rabbits in special cages. Blood was taken from the marginal vein of the ear into silicon treated test tubes and stabilized with sodium citrate in a ratio of 1:9. Measurements: blood-clotting time; specific blood-clotting parameters.

IMMOBILIZATION METHOD: Cage

RESULTS: The animals developed hypercoagulation after 14 days of hypokinesia; whole blood clotting time was 41% decreased by the end of the 2nd experimental week. By the 30th hypokinetic day there was a decrease in the total blood coagulatory capability (relative hypocoagulemia); clotting time increased by 14%, as compared to controls, and 95% as compared to the 14th experimental day. Specific factors: plasma heparin tolerance underwent the same trend changes as above; overall thromboplastic activity increased by the 14th day of hypokinesia and decreased by the 30th day; antiheparin activity first increased (2.2 times), then decreased (1.3 times) in the course of the experiment as compared to the control; prothrombin increased in 2nd week of hypokinesia (24%), remaining the same after 30 days; 14 day hypokinesia reduced thrombin time and free heparin time, 30 days extended these times; fibrinolytic activity diminished by 34% by the 14th experimental day, and remained depressed thereafter.

SOURCE: Space Biology and Aviation Medicine 12(6): 77-81, 1978

AUTHOR(S): Svistunov, N.T.

EXPERIMENT TITLE: Effect of Hypokinesia on Some Integral Indices of the Body Condition of White Rats

SUBJECTS: 46 Mature male Wistar rats

AREA OF STUDY: Behavior; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls; 2) 26 days hypokinesia; 3) 34 days hypokinesia. During the period of preparation the animals were weighed, the quantity of consumed food was determined, and the latent period of the defense reaction (LPDR) was measured. Temperature sensors were implanted. 8 days after surgical intervention, the rats were secured in corset restraints installed on a special platform. Food and water were not restricted. Measurements: general behavior; body temperature; body weight; LPDR.

IMMOBILIZATION METHOD: Corset and platform

RESULTS: The experimental animals rapidly adapted to confinement in a fixed state. During the experiment they were active, freely assumed different poses, ate food and drank water. The body temperature of rats during the entire course of the experiment was within the limits of physiological variations. Surgical intervention led to a brief decrease in weight of the animals. By the 13th day the weight of the animals attained the initial level and began to increase gradually. By the end of the 26th day, the rats had increased in weight an average of 12 gm (about 8%), the control rats had gained 20 gm (about 13%). By the 8th day after the experiment the weight of the animals corresponded to that of the controls. The weight dynamics of the rats during the 34-day experiments was similar to that for 26-day experiments. Both experiments revealed a statistically reliable shortening of the LPDR on the 3rd day of hypokinesia with normalization on the days which followed. Performance on the 1st day after hypokinesia was 60 and 50% respectively, and on the 8th day was 77 and 70% of the controls.

SOURCE: Space Biology and Aerospace Medicine 8(4): 121-124, 1974

AUTHOR(S): Swanson, G.T. and J.F. Lafferty

EXPERIMENT TITLE: Electrical Properties of Bone as a Function of Age,
Immobilization and Vibration

SUBJECTS: Male Sprague-Dawley rats, 60 days old

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Two series of animal experiments: 1) vibration and age - 12 hr of vibration daily at 25 Hz and 9.8 m/sec (1 G) until the ages of 180 and 240 days, controls were killed at 60, 180, 240, 343 and 410 days of age; 2) immobilization and age - right hind limbs immobilized in 5-cm plaster casts extending from the lower extremity to the pelvis until 95 days old when 4 animals were sacrificed, the other 6 had their casts removed but were not sacrificed until 133 days old. The left rear legs served as controls. Measurements: conductivity in rat tibiae (conductance was investigated by applying a potential difference across the prepared specimens and measuring current as a function of temperature).

IMMOBILIZATION METHOD: Plaster cast

RESULTS: The increase in cortical bone conductivity corresponded to the age-dependent increase in the inorganic portion of bone and bone density. Conductivity was decreased following bone demineralization by immobilization. Conductivity, as well as bone growth, was unaffected in rat limbs following prolonged exposure to vibration.

SOURCE: Journal of Biomechanics 5: 261-266, 1972

AUTHOR(S): Szöör, Á., A. Boross, G. Hollósi, T. Szilágyi, and L. Kesztyus

EXPERIMENT TITLE: Experimental Investigations on Hypokinesis of Skeletal Muscles With Different Functions. Changes in Muscle Weight, Protein and Contractile Properties

SUBJECTS: 80 Adult New Zealand rabbits (Oryctolagus domesticus) (3000±200 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Rabbits were mildly anesthetized with pentobarbital (Nembutal) iv and their right hind limbs were fixed in full extension by a plaster cast. 5, 10, 14, 28 or 42 days following fixation, rabbits were decapitated, exsanguinated, and the tetanic m. gastrocnemius and the tonic m. soleus muscles were isolated and excised. Corresponding muscles of the contralateral limb served as control. Measurements: water content of muscles; protein; myofibrillar proteins.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: Immobilization decreased considerably the masses of both muscles studied. Water content did not change substantially during atrophy. The total protein and myofibrillar protein contents of the immobilized muscles fell significantly. The tonic m. soleus atrophied sooner and more extensively than the m. gastrocnemius. Superprecipitation of the myofibrillar proteins of the immobilized muscles decreased 20-25% compared with controls.

SOURCE: Acta Biologica Academiae Scientiarum Hungaricae 28(2): 195-204, 1977

AUTHOR(S): Tabary, J.C., C. Tabary, C. Tardieu, G. Tardieu, and G. Goldspink

EXPERIMENT TITLE: Physiological and Structural Changes in the Cat's Soleus Due to Immobilization at Different Lengths By Plaster Casts

SUBJECTS: 27 Adult cats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Five groups: 1) 6 cats, untreated animals; 2) 5 cats, one hind limb immobilized in complete dorsi-flexion by plaster cast - soleus muscle maintained in the lengthened position (4 wk immobilization); 3) 6 cats, one hind limb immobilized in complete plantar-flexion, soleus muscle maintained in shortened position (4 wk immobilization); 4) 4 cats, one hind limb immobilized in full plantar-flexion (4 wk immobilization then 4 wk recovery after which the animals were killed); 5) 6 cats, one hind limb immobilized in full plantar-flexion for 4 wk, then the casts were removed and the limbs were replastered in an intermediate position between plantar- and dorsi-flexion for 4 more weeks. Animals were killed after the different experimental periods for soleus muscle analysis. Measurements: passive-length tension curves; muscle fibre length, sarcomere length and the total number of sarcomere along single teased fibers.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: Muscles that had been immobilized in the lengthened position showed no difference in their length-tension properties to those of normal muscles. However, those immobilized in the shortened position showed a considerable decrease in extensibility. Soleus muscles immobilized in the lengthened position were found to have 20% more sarcomeres in series than normal muscles while those immobilized in the shortened position had 40% less than normal muscles. When the plaster casts were removed from muscles that had been immobilized in the shortened position, the length-tension curves and sarcomere number returned to normal within 4 weeks. Muscles that were immobilized in a shortened position and then immobilized in a second position were found to rapidly adjust to the second position with respect to their passive length-tension properties and sarcomere number.

SOURCE: Journal of Physiology 224: 231-244, 1972

AUTHOR(S): Tache, Y., P. Du Ruisseau, J. Tache, H. Selye, and R. Collu

EXPERIMENT TITLE: Shift in Adenohypophyseal Activity During Chronic Intermittent Immobilization of Rats

SUBJECTS: Female adult Charles River CD rats (140-150 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Experiment 1: 8 hr of immobilization daily for 1, 3, 6, 10 or 15 days. The experimental animals were in a prone position; heads were inserted in an inverted u-shaped guard soldered to a metal plate and their limbs were fastened with adhesive tape to 4 specially-mounted metal strips. Control rats were left undisturbed in separate cages. Following immobilization, both experimental and control rats were weighed and killed by decapitation. Trunk blood was collected, and the ovaries, adrenals, thyroid, pituitary and thymus were removed for study. Experiment 2: intraventricular cannulation was performed in 2 groups of rats under Nembutal anesthesia 48 hr prior to immobilization (6 hr daily for 15 days). Ten μ l isotonic saline or synthetic LH releasing hormone (LH-RH) plus thyrotropin releasing hormone (TRH) dissolved in 10 μ l isotonic saline was injected iv 20 min before decapitation at the end of the immobilization period. A nonstressed, untreated group was decapitated at the same time. Plasma was collected. Measurements: ovarian, adrenal, thyroid, pituitary and thymus weight; body weight; corticosterone; growth hormone (GH); prolactin (PRL); luteinizing hormone (LH); follicle-stimulating hormone (FSH).

IMMOBILIZATION METHOD: Metal plate with head guard, tape, and metal strips

RESULTS: Experiment 1: 3-day immobilization inhibited body weight, and induced adrenal enlargement and thymus involution. 6-day immobilization caused atrophy of the ovaries and hypophysis. During later stages, rats showed a positive metabolic balance, and initial weight alterations of the endocrine glands either regressed or stabilized. On day 6, plasma corticosterone reached a peak which was maintained until the end of the experiment, but GH, LH, and FSH titers fell to 28, 39, and 55% of control values respectively following the 1st period of immobilization. Prolactin decreased by 30% after day 3; they then remained low, about 40-60% of control levels, though FSH on day 6 showed a transient but significant elevation to 180% of initial values. Experiment 2: A significant decrease in plasma FSH and LH concentrations occurred in immobilized, saline-treated rats, similar to that observed in Experiment 1. After 15 days of 6-hr daily immobilization, LH-RH and TRH injections produced dramatic increases in LH, FSH, PRL, and thyrotropin-stimulating hormone in plasma.

SOURCE: Neuroendocrinology 22: 325-336, 1976

AUTHOR(S): Takács, O., I. Sohár, T. Pelle, F. Guba, and T. Szilágyi

EXPERIMENT TITLE: Experimental Investigations on Hypokinesis of Skeletal Muscles with Different Functions. III. Changes in Protein Fractions of Subcellular Components

SUBJECTS: 50 Rabbits

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) plaster cast immobilization of the rabbits' right hind limbs for 5, 10, 14 and 28 days. Rabbits were exsanguinated, and the gastrocnemius and soleus muscles were removed, weighed, and processed by homogenization, centrifugation, separation, and washing. Measurements: levels of myofibrils and sarcoplasmic proteins.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: In both m.gastrocnemius and m.soleus, myofibrillar content decreased from the beginning of the test to the end at the 28th day; the total myofibrillar loss was greater in m.soleus (30%) than in m.gastrocnemius (25%). For both muscles, sarcoplasmic protein content increased from the start to the finish of the experiment; the total sarcoplasmic protein increase was greater in m.soleus (25%) than in m.gastrocnemius (20%). The slow tonic muscle m.soleus underwent greater changes due to hypokinesia than did the fast muscle, m.gastrocnemius.

SOURCE: Acta Biologica Academiae Scientiarum Hungaricae 28: 213-219, 1977

AUTHOR(S): Takács, O., I. Sohár, T. Szilágyi, and F. Guba

EXPERIMENT TITLE: Experimental Investigations on Hypokinesis of Skeletal Muscles with Different Function. IV. Changes in the Sarco-plasmic Proteins

SUBJECTS: 50 Rabbits

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) plaster cast immobilization of the rabbits' right hind limbs for 5, 10, 14 and 28 days. Rabbits were killed after immobilization in plaster; the gastrocnemius and soleus muscles were excised, weighed, and processed by homogenization, centrifugation, separation, and washing. The soluble protein fractions were obtained, samples of the dry protein powder were treated to lose the quaternary structure of the individual proteins, and to obtain their subunits. The subunits were separated by gel-electrophoresis, and the individual fractions were identified, then evaluated quantitatively with a densitometer. Measurements: relative amounts of the individual components calculated from density values.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: There was no change in the glyceraldehyde-3-phosphate dehydrogenase, creatine kinase and enolase activities. The enzymes lactate dehydrogenase, aldolase and the glycogenolytic enzymes showed a relative decrease in both muscles. Phosphoglycerate kinase, phosphoglucose isomerase and pyruvate kinase increased in both muscles. Changes of opposite directions were exhibited by myoglobin, myokinase and F-protein.

SOURCE: Acta Biologica Academiae Scientiarum Hungaricae 28(2): 221-230, 1977

AUTHOR(S): Takamori, M., R. Hazama, and M. Tsujihata

EXPERIMENT TITLE: Active State Properties of Denervated and Immobilized Muscle: Comparison With Dystrophic Muscle

SUBJECTS: Rabbits (2-2.5 kg)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls; 2) denervation - 10 rabbits, tibialis anterior muscle, right sciatic nerve was sectioned aseptically about 8 cm proximal to the tibialis anterior, electrophysiologic study 20-24 hr after denervation; 3) immobilization - 10 rabbits, tibialis anterior muscle, joint fixation - knee and ankle joints of the right limb were immobilized in mid-position by aseptic pinning. Electrophysiologic study 4 wk after pinning. Measurements: twitch and tetanus; contractile analyses - maximum twitch force (Pt), time from onset to the half-relaxation level of twitch (Tl/2R), maximum acceleration of twitch development (d^2Pt/dt^2), maximum tetanic force (Po), and maximum velocity of tetanus development (dPo/dt); staircase changes in twitch; post-tetanic changes in twitch; effects on contraction of isoproterenol hydrochloride and sodium caffeine. Comparative study: human dystrophic muscle - 29 patients, muscle contraction study performed with adductor pollicis with stimulation of ulnar nerve. Contractile analyses as above.

IMMOBILIZATION METHOD: Denervation; Pinning

RESULTS: Denervated muscle - reduction in Pt, associated with decrease in d^2Pt/dt^2 ; amplitude of action potentials evoked by nerve stimulation decreased, evoked action potentials were normal; less than normal staircase potentiation or a negative staircase was associated with a less than normal increase in d^2Pt/dt^2 ; post-tetanic potentiation of Pt was less than normal, and associated with less than normal potentiation in d^2Pt/dt^2 ; isoproterenol induced a decrease in Pt and a shortening of Tl/2R; caffeine caused greater than normal increases in Pt and d^2Pt/dt^2 . Immobilized muscle - marked prolongation of Tl/2R; marked reductions in Po and dPo/dt ; amplitudes of action potentials were normal; negative staircase associated with no change in d^2Pt/dt^2 - negative staircase phenomenon and post-tetanic prolongation of Tl/2R more pronounced in immobilized than denervated muscle; post-tetanic potentiation of Pt was less than normal; isoproterenol induced normal increases in Pt and normal prolongation of Tl/2R; caffeine caused less than normal increases in Pt, d^2Pt/dt^2 , and Tl/2R. Human dystrophic muscle: abnormal active state properties were found; contractile abnormalities - some prolongation of Tl/2R; decrease of d^2Pt/dt^2 ; decreased Po and dPo/dt .

SOURCE: Neurology 28: 603-608, 1978

AUTHOR(S): Terho, T. and K. Hartiala

EXPERIMENT TITLE: The Effect of Restraint and Some Ulcerogenic Agents on the Sulphation and Turnover Rates of Gastrointestinal Polysaccharides

SUBJECTS: Female Wistar rats (150-200 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: To produce experimental ulcers rats were fed ulcerogenic agents (cinchophen or salicylic acid) or subjected to restraint at 23°C, later 20°C, for 24 hr and received 8-V electrical shocks every 3rd sec. 0.1 mCi Na³⁵SO₄ in 0.5 ml 0.9% NaCl/100 gm was administered ip ½-4 hr before killing. Control and restraint rats were starved for 12 hr before and during restraint. Measurements: mucopolysaccharides; ulcer formation.

IMMOBILIZATION METHOD: Not stated

RESULTS: Restraint did not change the turnover rates of sulphomucopolysaccharides, but did cause a significant decrease in the sulfation of polysaccharides only when restraint was sufficiently effective to cause ulceration. The stronger the restraint, the greater the ulcer frequency.

SOURCE: Scandinavian Journal of Gastroenterology 5(3): 197-205, 1970

AUTHOR(S): Tharp, G.D. and J.L. Jackson

EXPERIMENT TITLE: The Effect of Exercise Training on Restraint Ulcers
in Rats

SUBJECTS: Male rats, Long-Evans, Sprague-Dawley (175-200 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Four groups: 1) runners were trained for 8 wk on treadmill (1 mph) for 1 hr daily, 5 days per week for 8 wk; 2) walkers trained on treadmill 3 days per week (2 mph for 10 min) for 8 wk; 3) sedentary group; 4) same as 1 and 2 but not restraint-cold stressed. After 5 wk groups 1-3 were starved for 24 hr, immobilized in restraint cages and placed in a refrigerator (5°C) for 4 hr. Measurements: presence and number of ulcers; heart weight/body weight rates.

IMMOBILIZATION METHOD: Cage

RESULTS: No significant differences in the number of ulcers or ulcer indexes per stomach were found between groups within each rat strain or between strains. Runners of each strain had a significantly lower body weight and higher heart weight/body weight ratio.

SOURCE: European Journal of Applied Physiology and Occupational Physiology
33: 285-292, 1974

AUTHOR(S): Thaxter, T.H., R.A. Mann, and C.E. Anderson

EXPERIMENT TITLE: Degeneration of Immobilized Knee Joints in Rats

SUBJECTS: 65 Adult Sprague-Dawley rats (120-140 days old)

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Four groups of 15 rats each, plus 5 controls: 1) denervated - knee denervation by high femoral, sciatic, and anterior obturator neurectomy; 2) immobilized weight bearing - knee immobilization in moderate flexion by pin fixation and internal Plexiglas splint; 3) immobilized/non-weight-bearing - knee immobilized as in group 2; skin of extremity removed; subcutaneous pouch applied; 4) immobilized, denervated - knee immobilized as in group 3, and denervated as in group 1. All animals maintained in cages in groups of 2-4 until sacrificed. 5 animals from each main experimental group killed 15, 45 and 90 days post-operation. 48 hr prior to sacrifice the animals were injected ip with buffered $\text{Na}_2\text{S}^{35}\text{O}$ (3 microcuries/ml body wt). After death, the entire knee joint was excised for histological and autoradiograph analysis. Unoperated knees were similarly processed and used for comparison. 3 control animals underwent sham operations (without denervation or immobilization). 2 remaining controls were not operated upon.

IMMOBILIZATION METHOD: Denervation; Internal fixation

RESULTS: Weight-bearing and non-weight-bearing immobilized knees underwent nearly identical progressive degenerative change. Denervated immobilized knees showed similar but less extensive degeneration. Knees which were only denervated showed few changes.

SOURCE: Journal of Bone and Joint Surgery 47-A(3): 567-585, 1965

AUTHOR(S): Thaxton, P. and D.M. Briggs

EXPERIMENT TITLE: Effect of Immobilization and Formaldehyde on Immunological Responsiveness in Young Chickens

SUBJECTS: Broiler chicks

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: The treatments were given at 3 weeks of age and consisted of: 1) 12-hr immobilization; 2) single iv 20% formaldehyde solution injections; 3) nonhandled controls. Eight groups of 6 birds for each treatment. The birds were immobilized by placing them dorsal side down and securing them with rubber bands placed around the feet and wings. Birds were immunized with injection of 1 ml 7% saline suspension of sheep red blood cells (SRBCs) 12 hr after treatment termination. Following SRBC injections, birds were bled at 3-day intervals for 15 days. Measurements: body weight; hemagglutinins.

IMMOBILIZATION METHOD: Rubber bands

RESULTS: Immobilization and formaldehyde injections did not suppress hemagglutinin levels at any time during the primary immune response. The body weights of the treated birds did not differ significantly from the controls 2 wk following the treatments.

SOURCE: Poultry Science 51: 342-344, 1972

AUTHOR(S): Thomaidis, V.Th. and T.S. Lindholm

EXPERIMENT TITLE: The Effect of Remobilization on the Extremity of the Adult Rat After Short-Term Immobilization in a Plaster Cast

SUBJECTS: 40 Male adult Sprague-Dawley rats (393.5 gm)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Two experimental groups: 1) right hind leg immobilized in a plaster cast for 4 wk and then killed 4 wk after removal of cast, 12 rats; 2) right hind leg immobilized in a plaster cast for 4 wk and then killed 16 wk after removal of cast, 12 rats. 8 nontreated rats were used as controls for each of the 2 experimental groups. Diet: common laboratory ration. Measurements: length of the left femur and tibia; hydrated gross bone density of both femurs and tibias; percentage bone area of both femoral midshafts; the "score" of both tibias.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: The length of the femur and tibia increased significantly and the hydrated gross density of the femur and tibia was significantly lower than controls after 4 wk of remobilization. The bone density of the femur and tibia from the immobilized leg was lower than the non-immobilized leg after 4 wk. The percentage bone area of the femur and the "score" of the right immobilized tibia were lower than those of the nonimmobilized extremity after 4 wk of remobilization.

SOURCE: Acta Chirurgica Scandinavica (Suppl. 467): 36-39, 1976

AUTHOR(S): Thompson, T.C.

EXPERIMENT TITLE: Experimental Muscular Atrophy

SUBJECTS: Rabbits

AREA OF STUDY: Muscular

OBJECTIVES: To determine the extent to which muscular atrophy can be limited by weight-bearing

PROTOCOL: Right hind limb was immobilized in casts from 1-6 wk. 2 groups:
1) weight-bearing allowed - right hind limb flexed in natural position;
2) non-weight-bearing - right hind limb fully extended.. One rabbit from each group was killed at the end of each week for 6 consecutive wk. Measurements: weight of immobilized muscles compared to corresponding ones of opposite side.

IMMOBILIZATION METHOD: Plaster of Paris spica cast

RESULTS: Atrophy was distinctly greater in those animals in the non-weight-bearing group, and was roughly proportional to the length of immobilization.

SOURCE: Journal of Bone and Joint Surgery 16: 564-571, 1934

AUTHOR(S): Thomsen, P. and J.V. Luco

EXPERIMENT TITLE: Changes of Weight and Neuromuscular Transmission in Muscles of Immobilized Joints

SUBJECTS: 26 Cats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Immobilization of the tibio-tarsal joint in one leg using a plaster bandage to produce 1 of 3 states of tension in the soleus and tibialis anticus. States of tension: hyperflexion (15 animals), hyperextension (8 animals), and intermediate (3 animals). The homologous muscle in the opposite leg served as the control. Four to 30 days later, under anesthesia, the sciatic nerve was stimulated by condenser discharges; curare was injected iv. Measurements: muscle weight; neuromuscular transmission.

IMMOBILIZATION METHOD: Plastic bandage

RESULTS: Immobilized muscles showed the same changes in neuromuscular transmission and were less sensitive to curare as found in tenotomized muscles. High frequencies of stimulation produced greater development of the 3rd stage of neuromuscular fatigue in relation to the 1st stage. Hyperflexion up to 14 days increased soleus weight and decreased tibialis weight; hyperextension produced the opposite.

SOURCE: Journal of Neurophysiology 7: 245-251, 1944

AUTHOR(S): Tikhonov, G.P. and Yu.P. Bizin

EXPERIMENT TITLE: Morphocytochemical Reaction of the Suprarenals and Thymic-Lymphatic System of Rats After Termination of Hypokinesia

SUBJECTS: 70 White common male rats

AREA OF STUDY: Endocrine; Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control; 2) hypokinetic. Hypokinesia was attained by placing the animals in special cages. Changes in the suprarenals and thymic-lymphatic system were studied during 20 days of restricted motor activity and also during the first 7 recovery days. In addition, a study was made of the rats' resistance to toxic doses of fluorochlorocarbon fluid after 20 days of hypokinesia. Measurements: body weight; weight of internal organs (suprarenals, thymus, spleen); absolute number of eosinophils in the peripheral blood and blood coagulation rate.

IMMOBILIZATION METHOD: Cage

RESULTS: By the 20th day of hypokinesia, the average body weight of the rats had decreased by 45 gm. A change in the relative weight of the suprarenals, thymus and spleen was noted. In a microscopic study of the suprarenals on the 20th day of hypokinesia, hypertrophy of the cortex due to thickening of the fascicular and reticular zones was noted. The dimensions of the glomerular zone were reduced. The cells were more compact in the fascicular zone in comparison with those in the control rats and contained a greater quantity of RNA. The lymphoid organs exhibited a considerable decrease in the number of lymphocytes but an increase in the number of macrophagal elements. A week later increased dimensions of the cortical parenchyma persisted in the suprarenals, but centers of delipoidization were no longer detected. The lipoids were uniformly distributed in all cortical layers. In the spleen, in the lymph nodes and thymus it was possible to observe hyperplasia of the plasmatic cells and an increase in the number of lymphocytes. The number of eosinophils in the peripheral blood returned to normal. However, blood coagulation time remained increased by almost a factor of three in comparison with the control. After 20 days of hypokinesia, the experimental rats showed increased resistance to fluorochlorocarbon.

SOURCE: Space Biology and Aerospace Medicine 8(5): 36-40, 1974

AUTHOR(S): Tikhonova, G.P., G.I. Solomin, Yu.P. Bizin, Yu.V. Shevchenko, and V.A. Shchirskaya

EXPERIMENT TITLE: Effect of Hypokinesia and Reduced Barometric Pressure on the Tolerance of Animals to Ethylacetate

SUBJECTS: 140 White male rats (170-240 gm)

AREA OF STUDY: Respiratory

OBJECTIVES: In title

PROTOCOL: Following 20 days of hypokinesia or 20 days of hypoxia (simulated altitude of 3,200 and 5,000 m), rats were acutely exposed to 25-69 mg/m³ ethylacetate vapors. Rats in a 90-day chronic experiment were exposed to 47 and 10 mg/m³ concentrations of ethylacetate vapors. Measurements: hemoglobin, erythrocytes, leukocytes and leukocytic formula of peripheral blood on the 15th, 30th, 60th and 90th day of inhalation; histology of organs after 90 days.

IMMOBILIZATION METHOD: Cage

RESULTS: After exposure to hypokinesia and hypoxia the sensitivity of the rats to an acute exposure of ethylacetate vapors increased two- or threefold. The chronic inhalation of the substance by the hypokinetic animals induced disturbances in the brain microstructure and renal pathology. The poisoned animals which retained normal motor activity exhibited serious pathological changes in the thyroid gland.

SOURCE: Space Biology and Aerospace Medicine 9(1): 43-49, 1975

AUTHOR(S): Tjawokin, W.W.

EXPERIMENT TITLE: A New Method to Produce Aortic Aneurysms in Rabbits
by Experimentally Restricting Their Movement

SUBJECTS: 12 Male chinchilla rabbits

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: A ligature of the thoracic aorta was performed on all rabbits. Five groups: 1) aorta diameter was not influenced by the ligature (2 rabbits); 2) the aortic passage was moderately constricted (2 rabbits); 3) the aortic lumen was severely restricted by the ligature (2 rabbits). One mo later rabbits from groups 1-3 were restrained, and 1 mo after restraint they were decapitated. Group 4) the operation was as in group 2, but 3 rabbits had moderate movement limitation rather than severe movement limitation; 5) 3 rabbits were kept in conventional cages with unlimited mobility, but were otherwise identical to group 3. Measurements: arterial pressure; total aorta pressure.

IMMOBILIZATION METHOD: Cage

RESULTS: Rabbits in group 1 and one rabbit in group 2 developed fusiform aneurysms under the ligature. The other rabbit from group 2 developed a pouchlike aneurysm over the ligature and a diffused aneurysm under it; the 2nd rabbit died 10 days after the beginning of restraint. Group 4 rabbits did not develop an aneurysm. Only one animal in group 5 developed an insignificant expansion of the aorta above and below the ligature. Arterial pressure varied from 103 in a group 1 rabbit to 175 mm Hg S in a group 5 rabbit.

SOURCE: Virchows Archiv. A. Pathological Anatomy and Physiology
351: 340-346, 1970

AUTHOR(S): Tkachenko, Z.Ya.

EXPERIMENT TITLE: Morphological Changes in Neurons of the Hind Limb
Reflex Arc During Long Term Immobilization

SUBJECTS: 12 Adult rabbits

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: The hind limbs of the rabbits were completely immobilized in a cast up to the 12th rib for 9, 15, 21, 25 and 31 days. The animals were then killed with an air embolism. Measurements: dystrophic changes in the spinal reflex arc by studying the spinal ganglia, posterior root and sensory and associative cells of the lumbar vertebra VII and sacral vertebra I.

IMMOBILIZATION METHOD: Cast

RESULTS: In the spinal ganglia, dystrophic changes of increasing severity with immobilization time were found, including pericellular edema, vacuolized neuroplasm, pycnotic changes, cytolysis and destruction. Chromatophilic matter decreased and was partly bleached, and amitotic division occurred. A portion of the sciatic nerve fibers were argentophilic, and some fragmentary decomposition occurred. Considerable dystrophic changes occurred in the motor nerve endings.

SOURCE: Fiziologichnyi Zhurnal 9(3): 383-384, 1963

AUTHOR(S): Tomanek, R.J.

EXPERIMENT TITLE: Limb Immobilization and the Diameters and Number of Nerve Fibers

SUBJECTS: Male albino rats (ages 35, 101 days)

AREA OF STUDY: Nervous; Muscular

OBJECTIVES: In title

PROTOCOL: Four groups: 1) young experimental rats (35 days old); 2) adult experimental rats (101 days old); 3) young control; 4) adult control. The experimental animals were anesthetized and immobilized by the application of a plaster cast to the right caudal extremity following the insertion of femoral and tibial pins. At the conclusion of the 11 wk immobilization period the right medial gastrocnemius nerve was excised and fixed under slight tension in 0.5% osmium tetroxide. The animals were then killed by an overdose of pentobarbital sodium. Transverse sections of the nerve were projected onto drawing paper, the myelinated fibers traced. Measurements: gastrocnemius muscle weight; number and mean diameter of myelinated fibers.

IMMOBILIZATION METHOD: Plaster of Paris cast

RESULTS: While the results demonstrated a disuse atrophy of the gastrocnemius muscle, the mean nerve fiber diameters of the immobilized groups did not differ from those of the controls. However, immobilization in adult animals was associated with a reduction in the frequency of fibers $>7\mu$. The number of myelinated fibers in nerves from animals immobilized during postnatal growth was significantly lower than those of the controls.

SOURCE: Journal of Comparative Neurology 134: 477-484, 1968

AUTHOR(S): Tomanek, R.J. and D.D. Lund

EXPERIMENT TITLE: Degeneration of Different Types of Skeletal Muscle Fibers. II. Immobilization

SUBJECTS: Male guinea pigs (500-600 gm)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Two groups: 1) immobilization - 12 guinea pigs, cast applied to right caudal extremity, extending from the toes to the mid-thigh medially and to the hip laterally, both the knee and the ankle joints were fixed at $90 \pm 5^\circ$; 2) controls. After either 5, 21, 45 or 90 days of immobilization, specimens were removed from the lateral and medial parts of the vastus lateralis and the soleus muscle. Measurements: extent of fiber atrophy through fiber diameter, investigations of fiber changes through electron microscopy; myosin ATPase and succinic dehydrogenase activity; hydroxyproline concentration.

IMMOBILIZATION METHOD: Cast

RESULTS: The red and white portions of the vastus lateralis contained predominantly fast-twitch-oxidative glycolytic (FOG) and fast-twitch-glycolytic (FG) fibers, respectively. In the soleus, virtually all the fibers were slow-twitch-oxidative (SO). After 21 days of immobilization, fiber diameters were markedly reduced in soleus, with little further change after longer immobilization. FOG and FG fiber diameters fell to their lowest values more slowly, the rate of decrement being half that of SO fibers. Myosin ATPase activity in the vastus lateralis did not differ from controls. A three-fold enhancement of hydroxyproline concentration occurred in the soleus of animals immobilized for 21 and 45 days; a slight enhancement in red vastus lateralis and no significant change in white. Compared to the FOG and FG fibers of the vastus lateralis, the SO fibers of the soleus were markedly atrophic. They also had reduced levels of histochemically demonstrable succinic dehydrogenase activity. While all fibers underwent some structural changes, consistent and extensive alterations were typical of SO fibers. Degeneration of myofibrils followed a pattern which was specific for fiber type and similar to that of denervation atrophy. In contrast to neurogenic atrophy, notable nuclear changes and dilatation of the sarcoplasmic reticulum were not characteristic of immobilization atrophy.

SOURCE: Journal of Anatomy 118: 531-541, 1974

AUTHOR(S): Tomaszewska, L., H. Kaciuba-Uscilko, B. Reklewska, J. Sobocinska, and S. Kozlowski

EXPERIMENT TITLE: Effect of Immobilization on Urinary Catecholamine Excretion and Blood-Thyroxine Level in Rats

SUBJECTS: 50 Albino rats

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 20 control; 2) 30 experimental rats were immobilized in special cages for up to 10 wk. 24-hr urinary catecholamine excretion was determined daily for both groups. The urine collected before and during the experiment was analyzed for free adrenaline and noradrenaline. Thyroxine level in the blood serum was estimated in rats immobilized for 10 days and 3, 6 and 8 wk and the controls.

IMMOBILIZATION METHOD: Cage

RESULTS: Within approximately 2 wk of immobilization, the amount of noradrenaline excretion stabilized after decreasing slowly, at a much lower level than before immobilization, also much lower than that of the control rats. Considerable variation in adrenaline excretion was observed between individual rats during the first few days of immobilization. Adrenaline excretion increased gradually from the end of the 1st wk of immobilization. The level of thyroxine in the blood of immobilized rats was lower than in controls after 10 days of immobilization. Marked decline of thyroxine level in comparison with control rats was observed after 6 and 8 wk immobilization.

SOURCE: Space Life Sciences 3: 174-176, 1971

AUTHOR(S): Tomaszewska, L. and Z. Araszkiewicz

EXPERIMENT TITLE: Calcium Balance in Rats Under Conditions of Prolonged Immobilization

SUBJECTS: 140 Male Wistar rats (180-235 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Four groups: 1) immobilized in cages for 3 wk, 60 rats; 2) immobilized for 6 wk, 40 rats; 3) immobilized for 9 wk, 20 rats; 4) controls, 20 rats. Three times per wk, urine and feces were analyzed. Measurements: calcium balance - calcium intake minus calcium excretion in urine (mg/24 hr) and feces (mg/24 hr); body weight.

IMMOBILIZATION METHOD: Cage

RESULTS: The mean amount of received calcium dropped sharply after 3 wk immobilization, but returned to the control level after 9 wk. The mean urinary calcium excretion decreased slowly from an initial level much higher than the controls. The mean fecal calcium excretion rose sharply after 3 wk immobilization over the control group and continued to rise slowly. The calcium balance after 3 wk was reduced by 36.4%, after 6 wk by 48.6% and after 9 wk by 51.84%.

SOURCE: Acta Physiologica Polonica 23(1): 89-93, 1972

AUTHOR(S): Tomaszewska, L. and P. Poczipko

EXPERIMENT TITLE: The Effect of Restriction of Physical Activity on the Metabolic Rate, Deep Body Temperature and Live Weight of Rats

SUBJECTS: 10 Male Wistar rats (235 gm)

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Experiments were carried out for 5 wk. During the 1st wk the rats were kept individually in large metabolic cages. For 3 wk they were kept in small plastic cages allowing small changes in body position, then returned for 1 wk to the metabolic cages. Temperature in the room was 21-24°C. Diet: standard pellet. Measurements: metabolic rate; rectal temperature; live body weight.

IMMOBILIZATION METHOD: Cage (small plastic)

RESULTS: The metabolic rate increased during the 1st wk of hypokinesia, remained on the same level for 2 further wk and 1 wk after return to the metabolic cages. Rectal temperature fell 1°C during the 1st day of hypokinesia, remained on that level for 1 wk, then gradually changed to slight hyperthermia. Body weight rapidly decreased during the 1st wk, then at a much smaller rate for the next 2 wk. Most of the loss in body weight was restored within 1 wk following termination of hypokinesia.

SOURCE: Bulletin de l'Academie Polonaise des Sciences 20(10): 743-746, 1972

AUTHOR(S): Tomaszewska, L., H. Kaciuba-Uscilko, and S. Kozlowski

EXPERIMENT TITLE: Calorigenic Effect of Adrenaline in Rats Under
Conditions of Restricted Motor Activity

SUBJECTS: Wistar rats (160-180 gm)

AREA OF STUDY: Metabolism and Energy Exchange; Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) baseline, hypokinesia, readaptation - 1 wk in metabolic cage to determine baseline resting metabolism and the calorigenic effect of adrenaline determined by adrenaline (50 µg/100 gm). After 10 and 21 days of hypokinesia same measurements were repeated; rats were then transferred to metabolic cages for 21 days and measurements were made on days 1, 10 and 21 of readaptation. Measurements: urine adrenaline; oxygen absorption.

IMMOBILIZATION METHOD: Cage

RESULTS: The rate of oxygen absorption increased during hypokinesia. After return to normal conditions the oxygen absorption was increased and returned close to the control value only after 21 days. After 10 and 21 days of hypokinesia the animals lacked a calorigenic reaction to the adrenaline injection. The calorigenic effect of adrenaline appeared weakly after 21 days of return of the animals to normal conditions. In the baseline period adrenaline excretion was constant. After hypokinesia the adrenaline excretion rose and levelled off at day 10. Return of the rats to normal conditions induced a gradual drop in adrenaline excretion.

SOURCE: Artificial Satellites 8: 75-80, 1973

AUTHOR(S): Tower, S.S.

EXPERIMENT TITLE: Persistence of Fibrillation in Denervated Skeletal Muscle and Its Nonoccurrence in Muscle After Tenotomy

SUBJECTS: 6 Cats

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Denervation: right brachial plexus and derivative nerves for forearm, accomplished by excising from high in the axilla to the elbow. Beginning 48 hr after operation and repeating at 2 day, 3 day, weekly and monthly intervals, the denervated muscle was examined for fibrillation. Tenotomized muscle (cut tendons) was examined for fibrillation in 2 long-surviving cats, 1-4 wk after tenotomy.

IMMOBILIZATION METHOD: Denervation; Tenotomy

RESULTS: Fibrillation was first observed on the 7th day after nerve section. After the 14th day, the phenomenon was demonstrable in any denervated muscle exposed for a period of up to 1 year (1 cat). Tenotomized muscle exhibited no trace of fibrillation at any time after tenotomy.

SOURCE: Archives of Neurology and Psychiatry 12: 219-223, 1939

AUTHOR(S): Tran, T.A. and R.V. Gregg

EXPERIMENT TITLE: Hypothermia in Restraint-Induced Gastric Ulcers
in Parabirotic Rats

SUBJECTS: 76 Adult white female rats, ARS Fisher 344 strain (180±25 gm)

AREA OF STUDY: Digestive; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Seven groups: 1) 12 parabiroted pairs with one rat restrained, unrestrained rat free to pull cart, 28 hr; 2) 12 parabiroted pairs with one rat restrained, unrestrained rat free to pull cart, 30 hr; 3) 5 parabiroted pairs unrestrained; 4) 3 rats restrained singly on cart, 24 hr; 5) 6 rats restrained singly on cart, 28 hr; 6) 3 rats unrestrained free to pull cart singly, 24 hr; 7) 6 rats unrestrained free to pull cart singly, 28 hr. Environmental temperature was maintained constantly 22°C ± 1. Animals deprived of food 24 hr before experiment. Diet: Purina laboratory chow and water. Measurement: body temperature; gastric ulcers.

IMMOBILIZATION METHOD: Mobile metal cart

RESULTS: Restrained rats, whether single or parabiroted, all developed macroscopic gastric ulcerations and showed a mean drop in body temperature of 6.3°C ± 0.7 after immobilization. Unrestrained parabiroted rats had a somewhat slower onset of ulceration than their restrained mates, but of those that ulcerated macroscopically body temperatures were found to drop 4.5°C 0.8. In the unrestrained parabiroted rats failing to develop macroscopic ulcers, temperature returned to control values after declining slightly during the first third of restraint period.

SOURCE: Gastroenterology 67(2): 271-275, 1975

AUTHOR(S): Tsaneva, N. and N. Stoyanova

EXPERIMENT TITLE: Changes in the Adrenalin and Noradrenalin Content of the Adrenal and Plasma During Limited Motor Activity and Supplemental Thermal Stress

SUBJECTS: 40 Albino rats (185 ± 5.4 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Four groups: 1) hypokinesia in cells for 25 days; 2) hypokinesia for 25 days then thermal stress for 5 sec in 65°C water, killed 30 min later; 3) same as group 2 but the animals were killed 90 min after thermal stress; 4) controls. Measurements: plasma adrenalin and noradrenalin; body weight.

IMMOBILIZATION METHOD: Cell (8 x 5.5 x 8 cm; length adjustable)

RESULTS: In groups 1-3, there was an initial drop in weight followed by a progressive increase. Immobilization caused a 10% reduction in the adrenalin values, with the level of noradrenalin in the plasma remaining unchanged. The reaction to thermal stress showed no appreciable differences compared to that of the controls.

SOURCE: Aggressologie 12(c): 81-86, 1971

AUTHOR(S): Tsvetov, Ye.P., S.N. Razin, and A.V. Rychko

EXPERIMENT TITLE: Functional-Morphological Parallels of the Hypothalamo-Pituitary-Adrenal System Response Reaction to Long-Term Hypokinesia

SUBJECTS: Mice, C57B1, BA1b/C and rats, Wistar

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Five groups: Mice - 1) immobilized for 2 wk in restraint cages; 2) same for 2 wk; and 3) controls. Rats - 4) immobilized for 4 wk; 5) 4 wk normodynamia. Measurements: body and adrenal weight. The neurosecretory substance in the frontal sections of the hypothalamus, supraoptic and paraventricular nuclei, and the hypothalamopituitary tract was determined using the Gamori-Gabou method. The adrenals were stained with Sudan-III to determine lipids.

IMMOBILIZATION METHOD: Cage

RESULTS: Progressive exhaustion and pathological reorganization of the HPAS morphofunctional structures took place after 2 and 4 wk hypokinesia which included a decrease in weight, cessation of growth, and hypertrophy of the adrenal fascicular layers.

SOURCE: Vrachebnoe Delo No.9: 9-14, 1975

AUTHOR(S): Tucek, S., D. Kostirova, and E. Gutmann

EXPERIMENT TITLE: Effects of Castration, Testosterone and Immobilization on the Activities of Choline Acetyltransferase and Cholinesterase in Rat Limb Muscles

SUBJECTS: Male Wistar rats

AREA OF STUDY: Muscular; Endocrine

OBJECTIVES: In title

PROTOCOL: The animals were anaesthetized by ether and the knee and ankle of the right hind limb were immobilized by inserting injection needles into the tibia through the distal end of the femur and through the calcaneus on the 40th and 41st day of life. Contralateral muscles served as controls. Animals with immobilized right soleus muscle were separated into 4 groups: 1) treated with testosterone for 5 days after immobilization; 2) treated with testosterone for 10 days after immobilization; 3) control to 5 days' treatment; 4) control to 10 days' treatments. A fifth group consisted of rats which were not operated on and not treated with testosterone. Other experiments involving castration and testosterone propionate administration were done. Measurements: choline acetyltransferase (ChAc); cholinesterase (ChE).

IMMOBILIZATION METHOD: Internal fixation with needles

RESULTS: After the soleus muscles of rats had been immobilized for 10 days, their ChAc activity was 56% and their weight 51% of control values. Testosterone did not alter the effect of immobilization on the ChAc and muscle weight.

SOURCE: Journal of Neurological Sciences 27: 363-372, 1976

AUTHOR(S): Tyavokin, V.V.

EXPERIMENT TITLE: Experimental Atherosclerosis in Rabbits with Motility Restriction

SUBJECTS: 33 Male chinchilla rabbits

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two series of experiments: 1) restriction of movement for 14-15 days in cholesterol-fed rabbits (9 experimental, 6 controls); 2) restriction of movement for 14 or 140 days in rabbits (11 experimental, 7 controls). Restriction of movement was achieved by placement of the animals in a wire cage with a floor plate. The rabbits were killed and subjected to necropsy. Measurements: cholesterol level; ECG; blood pressure; body weight; changes in aorta, coronary artery and myocardium.

IMMOBILIZATION METHOD: Cage (wire)

RESULTS: In the first series, only 3 rabbits survived the experiment. The remainder died within 2-10 days after restriction of movement. In all investigated experimental animals macroscopic changes were found on the aorta: roughening of the endothelium, atherosclerotic protuberances, and atherosclerotic ulceration. Restriction of movement hastened the development of experimental cholesterol atherosclerosis, changes in the myocardium were more marked than atherosclerotic changes in the coronary arteries. In the second series, macroscopic changes in the aorta: roughening of the endothelium and protuberances were found. The roughening of the endothelium was also found in rabbits who died within 5-7 days after the onset of restricted movement. In 1 rabbit the development of protuberances was observed after 2 wk of restricted movement. After 140 days of restricted movement there was a greater proliferation of subendothelial cells. There were no arteriosclerotic changes in the coronary artery; the changes in the myocardium were of the same character as in the first experimental series.

SOURCE: Cor et Vasa 9(1): 68-76, 1967

AUTHOR(S): Tyavokin, V.V.

EXPERIMENT TITLE: Blood Sugar Dynamics in Rabbits with Experimental Atherosclerosis and Coronary Insufficiency Produced by Limitation of Mobility

SUBJECTS: Rabbits

AREA OF STUDY: Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Experimental atherosclerosis and coronary insufficiency was produced by limitation of movement. Experiments: 1) blood sugar investigated in 38 rabbits; 2) blood corticosterone level investigated in 22 rabbits; 3) blood and myocardium catecholamine concentration in 13 and 14 respectively; 4) pancreas of 6 rabbits was investigated histologically.

IMMOBILIZATION METHOD: Not stated

RESULTS: Despite the lowering of corticosterone and adrenalin levels in blood, the blood sugar level was raised. Abnormalities of the pancreas was found in five of the six rabbits examined.

SOURCE: Bulletin of Experimental Biology and Medicine 66(12): 1320-1321, 1968.

AUTHOR(S): Tyavokin, V.V.

EXPERIMENT TITLE: Experimental Coronary Sclerosis Induced By Immobilization of Rabbits. A New Model of Arteriosclerosis

SUBJECTS: 79 Male chincilla rabbits

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 58 experimental rabbits immobilized in cages for 55 days; 2) 12 control rabbits kept in ordinary cages for 23-55 days; 3) 9 control rabbits kept in ordinary cages for 12 mo. Blood samples and EKGs were taken at specific time intervals. Diet: normal. Measurements: blood cholesterol; blood corticosteroids; glutamic oxaloacetic transaminase (GOT) activity blood serum; blood pressure; degree of macro- and microscopic alterations in the aorta, coronary arteries and myocardium.

IMMOBILIZATION METHOD: Cage

RESULTS: Thirty rabbits died before the end of the experiment, most demonstrated macroscopic changes in the aorta; roughness of the endothelium was seen as early as day 1. The coronary arteries showed similar changes, but no deposit of sudanophilic substances. After immobilization for 10-20 days, changes in the coronary vessels ranged from subendothelial edema to sclerosis with total occlusion of the vessels. In the myocardium, prolonged immobilization caused circumscribed necroses and collagenization of the argyrophilic fiber network. Nearly all rabbits showed signs of coronary insufficiency. GOT activity in the blood serum was significantly different at the beginning and end of the experiment. Arterial blood pressure was unchanged.

SOURCE: Virchows Archiv. Abteilung A. Pathologische Anatomie, Pathology 346: 29-45, 1969

AUTHOR(S): Tyavokin, V.V.

EXPERIMENT TITLE: Effect of Hypodynamia on Total Cholesterol and Lipoprotein Concentrations in the Blood

SUBJECTS: 48 Rabbits

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 16 control rabbits; 2) immobilization of 32 rabbits for up to 140 days so that atherosclerosis with coronary insufficiency was produced without exogenous administration of cholesterol. Measurements: total cholesterol in blood; serum lipoproteins.

IMMOBILIZATION METHOD: Not stated

RESULTS: Ten days following hypodynamia, the blood cholesterol level decreased, but after 30 days it markedly increased. Two wk after hypodynamia the α -lipoprotein concentration was reduced by almost two thirds, but β -lipoprotein concentration increased.

SOURCE: Bulletin of Experimental Biology and Medicine 69(5): 510-511, 1970

AUTHOR(S): Tyavokin, V.V.

EXPERIMENT TITLE: Effect of Limitation of Muscular Activity (Hypodynamia) on the Blood Serum Protein Concentration

SUBJECTS: 27 Male chinchilla rabbits

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 10 control; 2) 17 experimental. The mobility of experimental animals was sharply restricted for 7 and 14 days. Measurements: serum protein fractions; total protein concentration.

IMMOBILIZATION METHOD: Not stated

RESULTS: The albumin concentration decreased and globulin concentration increased in blood serum, with a marked increase in the β -globulin concentration. Total protein concentration was unchanged. There were very few changes in any of the indices for controls.

SOURCE: Bulletin of Experimental Biology and Medicine 74(9): 1049-1050, 1972

AUTHOR(S): Tyavokin, V.V.

EXPERIMENT TITLE: The Mechanism of Development of Aortic Aneurysm in Rabbits During Limitation of Their Mobility

SUBJECTS: Male chinchilla rabbits

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Six groups: in each group a ligature was placed on the thoracic (group 1-5) or abdominal (group 6) region of the aorta. One month later they were kept hypokinetic in cages for a period of 2 months. The groups differed in the amount of constriction of the ligature. Group 5 animals received a ligature but were placed in normal cages for 2 months. Group 6 animals had the ligature placed at the level of the renal arteries and were kept hypokinetic for 2 months. Measurements: the pressure in the common carotid prior to killing; presence of aneurysms.

IMMOBILIZATION METHOD: Cage

RESULTS: The production of aneurysms depended on: 1) the degree of limitation of mobility of the animal; 2) localization of the ligature; 3) degree of compression of the aorta by the ligature. Aneurysms were successfully produced in the thoracic region using both the ligature and natural constrictions by the animals' hiatus aorticus. In the case of the abdominal ligature renal disorders were both a result and a contributing factor to the formation of abdominal aneurysm of the aorta.

SOURCE: Kardiologiya 12: 139-143, 1972

AUTHOR(S): Uhthoff, H.K. and Z.F.G. Jaworski

EXPERIMENT TITLE: Bone Loss in Response to Long-Term Immobilization

SUBJECTS: Young adult Beagle dogs (7-13 kg)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Immobilization: right foreleg, through application of spica cast. Duration: 2-40 weeks; dogs were killed one at a time at 2, 4, 6, 8, 12, 16, 20, 24, 32 and 40 wk; the third metacarpal, radius, ulna and humerus were removed for analysis of the contribution of the periosteal, Haversian and endosteal envelopes to bone loss. Diet: normal. Measurements: histodynamic response, by means of radiomorphometry and histomorphometry. Each dog received 20 mg/kg of body weight of tetracycline iv 10 and 3 days before death.

IMMOBILIZATION METHOD: Padded shoulder spica cast

RESULTS: Total cortical bone loss: marked decrease in outside diameter; decrease in bone density; decrease in cortical thickness and in the total area of cross-section and expansion of the medullary cavity (third metacarpal at 40 wk). Temporal pattern of cortical bone loss: 3 stages - 1) rapid initial loss of bone, reaching its maximum at 6 wk (16% of original mass); all 3 bone envelopes contributed; rapid reversal followed, with the bone mass approaching the control values between 8 and 12 wk after immobilization; 2) slower, longer lasting bone loss 24-32 wk after immobilization; periosteal envelope was the main contributor (80-90% of loss); 3) maintenance of bone mass, which was reduced by 30-50% of original values. The greatest total bone loss occurred on the periosteal envelope in all cases. The percentage of loss was greatest in the third metacarpal and least in the humerus. The extent of resorption surface increased parallel to the phase of bone loss; formation surface did not show any striking differences between the experimental and control sides.

SOURCE: Journal of Bone and Joint Surgery 60-B(3): 420-429, 1978

AUTHOR(S): Vanamee, P., S.J. Winawer, P. Sherlock, M. Sonenberg, and M. Lipkin

EXPERIMENT TITLE: Decreased Incidence of Restraint-Stress Induced Gastric Erosions in Rats Treated with Bovine Growth Hormone

SUBJECTS: 65 Female CFE rats (150-200 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control rats; 2) experimental rats were restrained by stapling them into envelopes made of aluminum window screen. Immediately upon restraint and 10-hr later experimental rats received 5 mg bovine growth hormone sc; controls received 1 ml of buffer sc. Rats were anesthetized with ether at 24 hr and their stomachs removed and examined. Measurements: number of animals developing ulcers; number per animal; severity of erosions.

IMMOBILIZATION METHOD: Aluminum window screen envelope

RESULTS: Growth hormone provided partial but significant protection against restraint-stress produced erosions both in terms of erosion incidence and severity.

SOURCE: Proceedings of the Society for Experimental Biology and Medicine 135(2): 259-262, 1970

AUTHOR(S): Vasil'yev, P.V., N.N. Uglova, A.I. Volozhin, and Y.Ye. Potkin

EXPERIMENT TITLE: Investigation of Some Blood Indices in White Rats
Exposed to Sixty-Day Hypokinesia

SUBJECTS: 100 Male rats (180-210 gm)

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) experimental rats were kept for 60 days in individual cages of metal screening which restricted movement but did not prevent animal feeding and water intake. Measurements: volume of circulating plasma (VCP), volume of circulating blood (VCB), hematocrit index, number of erythrocytes, hemoglobin content and weight of subjects on days 5, 10, 20, 40 and 60 of hypokinesia.

IMMOBILIZATION METHOD: Cage (metal screening)

RESULTS: The weight of hypokinetic rats decreased by 17% during the first 5 days, after which it stabilized. Under prolonged hypokinesia, the animals developed insignificant changes in the total VCP and VCB; however, VCP and VCB increased with computation per 100 gm of animal weight. Increases occurred in the hematocrit index, number of erythrocytes, and hemoglobin content.

SOURCE: 'Space Biology and Medicine 7(2): 16-21, 1973

AUTHOR(S): Vasil'yev, P.V., V. Ye. Belay, N.A. Gaydamakin, G.D. Glod, V.F. Lysak, Ye.P. Mel'nikova, S.V. Petrukhin and N.N. Uglova

EXPERIMENT TITLE: Effect of Prolonged Hypokinesia on the Course of Acute Aseptic Inflammation

SUBJECTS: 390 Albino rats (150-200 gm)

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: Three series 1) effect of different periods (15, 28 and 60 days) of hypokinesia; 2) the effect of duration of readaptation (1, 3 and 7 days); 3) the distinctions of development of an inflammatory process against a background of continued effect of restricted mobility. Inflammation: produced by administration of 0.1 ml of 3% formalin under the plantar aponeurosis of the hind limb under aseptic conditions. Measurements: dynamics of inflammatory reaction assessed according to local changes and systemic changes; severity of edema (through oncometry); incidence of suppuration; skin temperature; blood leukocytes; eosinophils; fibrinogen.

IMMOBILIZATION METHOD: Not stated

RESULTS: Inflammatory reaction symptoms were more severe and complications more frequent in experimental rats in all cases. There was more marked edema and delayed resorption; increased temperature of the inflammatory focus; increased number of infectious complications involving necrotic foci and ulcerations; enhanced alteration processes and inhibited formation of the demarcation zone. Resistance to phlogogenic stimulation dropped to minimum during the first 2 hypokinetic wk; it slowly returned to normal but did not recover entirely even after 60 days of hypokinesia. Blood fibrinogen declined after 15 and 28 day hypokinesia; readaptation for 7 days after hypokinesia led to restoration of blood fibrinogen level. Readaptation time served, in most cases, to lessen the severity of the inflammatory reaction. Inflammation after prolonged hypokinesia was associated with a distinctly attenuated neutrophil reaction, lack of phases in dynamics of total leukocyte content and greater eosinopenia.

SOURCE: Space Biology and Aerospace Medicine 11(4): 51-57, 1977

AUTHOR(S): Videman, T., J.-E. Michelsson, R. Rauhamäki, and
A. Langenskiöld

EXPERIMENT TITLE: Changes in ^{35}S -Sulphate Uptake in Different Tissues
in the Knee and Hip Regions of Rabbits During
Immobilization, Remobilization and the Development
of Osteoarthritis

SUBJECTS: Adult rabbits (over 9 mo old)

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Rabbits' knees were immobilized in extension by means of a plastic splint or by bandaging the knee region. 3 groups: 1) 16 animals immobilized for periods of 1 to 130 days - 8 rabbits were killed one day after injection of ^{35}S -sulphate (2.5 mCi ia) and removal of the immobilizing bandage and 8 were killed before the bandage was removed; 2) 6 rabbits whose right knee was immobilized for 40 days after which the splint was removed and the limb remobilized 4-30 days before killing; animals were given sulphate injections 1 day before killing; 3) 6 rabbits - 3 had one knee immobilized for 2 wk and 3 for 4-6 wk. Measurements: the ^{35}S -sulphate uptake in ligaments, cartilage and bone was studied by scintillation counting and by autoradiography.

IMMOBILIZATION METHOD: Plastic splint; Bandaging

RESULTS: Degenerative changes were seen in the knee and hip of the immobilized limbs after 10 days of immobilization. The capsule of both the knee and the hip joint was thickened. The severity of the degenerative changes in the joints of the rabbits was directly correlated with the length of immobilization. ^{35}S -sulphate uptake in the joint regions of an immobilized limb was modified at a stage when no histological or radiological changes could be demonstrated. Immobilization and remobilization both distinctly increased the ^{35}S -sulphate uptake in the tissues of the restrained limb. The first marked changes were found in the ligaments and the articular cartilage as early as 4 days after immobilization. Thickening was induced in ligaments, joint capsules, and menisci.

SOURCE: Acta Orthopaedica Scandinavica 47: 290-298, 1976

AUTHOR(S): Vikhert, A.M., V.I. Metelitsa, V.D. Baranova, and I.Ye. Galakhov

EXPERIMENT TITLE: Morphological and Biochemical Changes in Rabbits
Subjected to Considerable Limitation of Mobility

SUBJECTS: 30 Male chinchilla rabbits (2.5 kg)

AREA OF STUDY: Circulatory; Metabolism and Energy Exchange

OBJECTIVES: To determine the nature and etiology of changes in the aorta, coronary arteries, and myocardium following immobilization

PROTOCOL: Two groups: 1) 10 controls; 2) 20 immobilized. Blood samples obtained on days 10, 20 and 30. 15 of the experimental animals died at various stages due to symptoms of cardiac and cardiopulmonary insufficiency. The remaining five rabbits were killed on days 19, 20, 23, 29 and 30 after immobilization. Diet: normal. Measurements: total cholesterol, lipoproteins, triglycerides, and total lipids in the blood.

IMMOBILIZATION METHOD: Not stated

RESULTS: Experimental animals lost 500 gm of body weight over 30 days while the controls gained weight. No changes were observed in lipid metabolic parameters at the end of the experiment. Cholesterol was slightly but not significantly increased on day 10. Control animals did not show any significant changes in lipoprotein fraction. Autopsy of all the dead animals indicated a plethora of the parenchymatous organs; the hearts of the experimental animals were flaccid. One showed hydropericarditis, 1 pyothorax, and 5 pneumonia. The aorta showed the following pathological changes: roughness of the intima, pits, depressions, and aneurysms. Pathological changes were noted in the middle layer of the aorta. Myocardial changes included tissue splitting and edema of the walls of the fine intramural arteries and constriction of the arterial lumina. The myocardium also contained capillary stasis, fatty dystrophy, necrobiosis, and necrosis of small groups of muscle fibers.

SOURCE: Kardiologiia 12: 143-146, 1972

AUTHOR(S): Vinogradov, V.N., V.G. Petrukhin, and I.V. Fedorov

EXPERIMENT TITLE: Morphological Changes Produced in Animal Organs by Prolonged Hypodynamia and Subsequent Physical Exertion

SUBJECTS: Albino rats; Dogs

AREA OF STUDY: Metabolism and Energy Exchange; Muscular; Circulatory

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 15 day hypodynamia - 30 rats, plaster casts, 6 of the animals were subsequently exposed to physical exertion (swimming - 30 mins); 2) 100 day hypodynamia in small cage - 12 rats and 2 dogs, subsequent exposure to radial accelerations; 3) controls - 3 dogs, 13 rats exposed to radial accelerations. Measurements: heart, skeletal muscles, liver, and adrenals histology; content of lipids, cholesterol, ribonucleoproteins, glycogen; succinate dehydrogenase and alkaline phosphatase activity; fuchsinophilic degeneration of the muscle fibers; thickness of skeletal muscle fibers, dry residue of the skeletal muscles; weight of organs.

IMMOBILIZATION METHOD: Cage; Cast

RESULTS: 15 day hypodynamia: animal weight fell an average of 15 gm; glycogen content in the sarcoplasm of the muscle cells decreased; succinate dehydrogenase activity increased and alkaline phosphatase decreased in the liver; adrenal weight increased; content of lipids and cholesterol in the cytoplasm of cells of the zona fasciculata was reduced; content of ribonucleoproteins and succinate dehydrogenase activity increased; the weight of lower limb muscles was reduced. The muscle fibers showed well marked cross striations and were reduced in thickness; the dry residue of the skeletal muscles was unchanged. The glycogen and uptake of labeled amino acids into muscle fibers was less than in controls. In the 6 rats exposed to physical exertion after 15-day hypodynamia, fuchsinophilia of individual fragments of the heart muscle fibers was found, in addition to the changes described above. 100+ day hypodynamia with radial accelerations: weight was 53-61% of the controls. There was considerable structural changes - petechial subpleural hemorrhages were found in the lungs of 6 rats; vacuolation or perinuclear edema of individual groups of muscle fibers and fuchsinophilic degeneration of their fragments were present in the heart of all experimental animals sacrificed 3 days after radial acceleration. There were marked differences in the glycogen content in the liver of subjects sacrificed 30 min after overloading.

SOURCE: Bulletin of Experimental Biology and Medicine 65(6): 682-684, 1967

AUTHOR(S): Volozhin, A.I.

EXPERIMENT TITLE: Effect of Hypoxic Hypoxia and Hypercapnia on Calcium, Inorganic Phosphorus, and Total Protein in the Blood of Rats During Hypodynamia

SUBJECTS: 282 Common white rats (160-180 gm)

AREA OF STUDY: Blood

OBJECTIVES: In title

PROTOCOL: Two series of experiments: Experiment 1 - 108 rats in 4 groups: 1) control; 2) hypodynamia; 3) hypoxic hypoxia (7,000 m); and 4) hypodynamia and hypoxia. Experiment 2 - 174 rats in 4 groups: 1) control; 2) hypodynamia; 3) hypercapnia (5% CO₂); and 4) hypodynamia plus hypercapnia. Hypodynamia was created by keeping the rats in tight cages made from wire screening. On days 20 and 30 of the experiment, the animals were bled and the blood analyzed. Measurements: calcium, inorganic phosphorus, and total protein in blood.

IMMOBILIZATION METHOD: Cage (tight)

RESULTS: The hypodynamic rats exhibited an increased calcium concentration and a decreased inorganic phosphorus and total protein content. Hypoxic hypoxia did not normalize the same parameters in hypodynamic rats. Inorganic phosphorus and protein in hypodynamic and hypercapnic rats was higher than in hypodynamic-only rats.

SOURCE: Space Biology and Medicine 5(2): 20-27, 1971.

AUTHOR(S): Volozhin, A.I., P.V. Vasil'yev, N.N. Uglova, and V.Ye. Potkin

EXPERIMENT TITLE: Status of Calcium Metabolism in the Calcified Tissues of Rats During Prolonged Hypodynamia and Thyrocalcitonin Administration

SUBJECTS: 180 Common male rats (120-130 gm)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Each animal was injected with 2 μC Ca^{45}sc . Seventy days after injecting the isotope the rats were divided into 4 groups: 1) controls; 2) animals in a state of hypodynamia; 3) animals administered thyrocalcitonin (TCT); and 4) animals exposed to hypodynamia and administered TCT. Hypodynamia was created by placing the rats in close cages. Rats in groups 3 and 4 were sc injected daily with 5 μg of an aqueous solution of a complex preparation of TCT with polyvinyl pyrrolidone (PVP). Animals in groups 1 and 2 were injected daily only with PVP. On days 5, 10, 20, 40 and 60 the rats (8-10 in each group) were decapitated and the calcium concentration was determined in the blood serum. The content of ash, total calcium, and the quantity of Ca^{45} in the teeth and bones were also determined.

IMMOBILIZATION METHOD: Cage (close)

RESULTS: In comparison with the controls, hypodynamia decreased the increment in the weight of skeletal bones to a considerable extent. The mineral content decreased in the hindleg, scapular and mandibular bones, increased in the parietal and maxillary bones, and remained unchanged in the shoulder bones. Hypodynamia considerably reduced the rate of Ca^{45} resorption from the molars and the nonreadily exchangeable bone fraction. Daily injections of 5 μg of TCT in combination with polyvinyl pyrrolidone to nonrestrained rats also caused a decrease in the Ca^{45} level in their calcified tissues. Injections of the drug to restrained animals exerted an opposite effect: the renovation rate of the nonreadily exchangeable fraction increased in comparison with that in animals exposed to hypodynamia alone. The drug exerted an insignificant effect on the growth rate of skeletal bones in restrained rats.

SOURCE: Space Biology and Medicine 6(3): 12-19, 1972

AUTHOR(S): Volozhin, A.I., V.S. Shashkov, B.S. Dmitriyev, B.B. Yegorov, V.I. Lobachik, and A.I. Briskin

EXPERIMENT TITLE: Effectiveness of Using Thyrocalcitonin for the Prevention of a Calcium Metabolic Disorder in the Mineralized Tissues of Rabbits with 30 Days of Hypokinesia

SUBJECTS: 98 Chinchilla rabbits (2500±220 gm)

AREA OF STUDY: Skeletal; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Calcium metabolism in the bones and teeth of rabbits was studied using Ca^{45} in the form of a chloride salt dissolved in an isotonic NaCl solution, which was injected in 50 μcurie doses into the marginal vein of the ear, regardless of the animal's weight. Four series of experiments: I - Ca^{45} was injected on day 29 of hypokinesia and the animals were sacrificed after 24 hr; II - Ca^{45} was injected 24 hr before the beginning of the experiments; III - 30 days before; IV - 60 days before. The rabbits of each series were divided into 4 groups of 5-7 animals; 1) controls; 2) administered thyrocalcitonin (TCT); 3) hypokinesia for 30 days; 4) hypokinesia and administration of TCT. Hypokinesia was induced by placing the rabbits in special cages with movable walls. The TCT preparation, dissolved in distilled water, was injected sc twice a day (morning and evening) at a rate of 30 MRC (IU) of hormone per day for each rabbit. The rabbits were sacrificed by air embolism and the calcanei, tibiae, femora, humeri, scapulae, parietals, 2nd cervical vertebrae, and upper and lower maxillae were removed. Molars and incisors were extracted from the upper maxillae. Measurements: ash content in teeth and bones; absolute and relative tissue weight; Ca^{45} uptake.

IMMOBILIZATION METHOD: Cage (with movable walls)

RESULTS: Hypokinesia led to a considerable lag in weight gain for the skeletal bones, reduction in Ca^{45} uptake, and an increase in isotope resorption rate in the rapidly metabolized fraction of extremity bones. Ca^{45} content in the teeth and maxillae increased. Injection of thyrocalcitonin produced a distinct normalizing effect of Ca^{45} uptake and resorption in the mineralized tissues of rabbits kept hypokinetic.

SOURCE: Patologicheskaya Fiziologiya i Eksperimentalnaya Terapiya 10(2): 42-46, 1974

AUTHOR(S): Volozhin, A.I., L.I. Stekol'nikov, N.N. Uglova, and V.Ye. Potkin

EXPERIMENT TITLE: Incorporation of Glycine-2-C¹⁴ in Acid-Insoluble Proteins of Rat Bones and Teeth During Hypokinesia and Administration of Thyrocalcitonin

SUBJECTS: 95 Albino mongrel male rats (120-130 gm)

AREA OF STUDY: Skeletal; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Four groups: 1) controls; 2) hypokinesia; 3) administered thyrocalcitonin (TCT); 4) hypokinesia and administered TCT. Hypokinesia was induced by placing the rats in close cages. Animals in groups 3 and 4 were daily given a sc administration of 5 µg of a complex preparation of TCT with polyvinylpyrrolidone (PVP). Within 5, 10, 20, 40 and 60 days after the start of the experiment the rats (4-5 from each group) were given sc injections of 2 µCi each of glycine-2-C¹⁴ diluted in a physiological solution. A day after administration of the isotope the animals were decapitated and the total protein content was determined in the blood plasma. The molars, incisors, lower and upper maxillary, humeral, femoral and tibial bones were removed and prepared for analyses.

IMMOBILIZATION METHOD: Cage (close)

RESULTS: Hypokinesia for 5-60 days resulted in a suppression of the incorporation of glycine-2-C¹⁴ into the total acid-insoluble proteins of the bones of the extremities and an increase in the teeth and mandibular-maxillary bones. Administration of thyrocalcitonin to rats during hypokinesia normalized the incorporation of glycine into the total acid-insoluble proteins of the bone tissue. The concentration of total blood protein dropped in the hypokinetic animals; in groups 3 and 4, there was an increase on the 5th and 10th days then a decrease on the 40th and 60th days.

SOURCE: Farmakologiya i Toksikologiya 37(2): 223-226, 1974

AUTHOR(S): Volozhin, A.I., M.P. Pavlova, I.Sh. Muradov, G.P. Stupakov, and V.A. Korzhen'yants

EXPERIMENT TITLE: Effect of Six-Month Hypokinesia in Dogs on Mineral Component, Reconstruction and Mechanical Properties of Bone Tissue

SUBJECTS: 16 Male and female dogs, 1½-2 yr of age (8-12 kg)

AREA OF STUDY: Skeletal

OBJECTIVES: In title

PROTOCOL: Two groups: 1) hypokinesia for 6 mo in lying position in metal cages, 8 dogs; 2) controls, 8 dogs. 6 of each group administered Ca^{45} , 100 mCi/10 kg iv on 180th day. Measurements: mineral saturation of Ca^{45} in maxillary, humeral, femoral and tibial bones, incisor, premolars, molars, diaphyses of long bones, heads of humerus and femur, trochanter major of femur and tubercle major of the humerus; histology of bone diaphyses, x-rays of femoral and humeral bones, mechanical properties of femur and humerus.

IMMOBILIZATION METHOD: Cage (metal)

RESULTS: After hypokinesia the inclusion of Ca^{45} was increased in the diaphysis of the femur and trochanter major and reduced in the diaphysis of the humerus. The number of vascular canals over 80 μm wide was increased. An increase was found in the indices of mineral saturation of the microstructures of all the zones of the diaphysis of the humerus and in the femur with the exception of the subperiosteal zone. The thickness of the layer of the general plates of long bones in experimental animals was smaller especially in the subperiosteal zone of the femur. Hypokinesia caused no change in the mechanical properties of the long bones.

SOURCE: Patologicheskaya Fiziologiya i Eksperimentalnaya Terapiya
No.6: 34-38, November-December 1976

AUTHOR(S): Walcher, K. and H. Stuerz

EXPERIMENT TITLE: Does Immobilization and Pressure Bearing of a Joint
Result in Ossification in an Animal Experiment

SUBJECTS: 151 Adult rabbits

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Immobilization and compression of the knee joint was achieved with a pressure bolt which was introduced in a right angle flexed position from the head of the tibia transarticular in the sagittal plane. The use of the pressure bolt allowed absolute fixation of the joint. The compressive forces were set between 4000 and 24,000 p with 2000 p difference in each case; 5-7 rabbits received the same degree of spring compressions (low, medium and high spring pressure groups). One animal from each group was killed after 14 days, 1, 2, 3 and 6 mo. The control groups were composed of animals whose knee joints were immobilized without compression, and animals which had only the right shin amputated. 4 to 8 days prior to sacrifice, the rabbits received oxytetracycline 50 mg/kg iv; 6 hr before sacrifice, S^{35} 2 mg/kg was given iv. Measurements: condition of the menisci; deformation of the joint elements.

IMMOBILIZATION METHOD: Bolt

RESULTS: Following immobilization for 14 days to 4 wk, there was still a residual mobility of approximately $30-50^{\circ}$, after which residual mobilities of 10 to 20° could be seen. After 3 mo or more, a fibrous stiffness developed which allowed only slight oscillating movements. Following immobilization for 6 mo, and especially when using higher pressures, complete stiffness of the joint was observed. The menisci became narrow, thin, flaccid, glassy and transparent as the length of the experiment increased.

SOURCE: Archiv fuer Orthopaedische und Unfall-Chirurgie 71: 216-247, 1971

AUTHOR(S): Walcher, K.

EXPERIMENT TITLE: Does Immobilization and Pressure in Animal Experiments Induce Ankylosis

SUBJECTS: Rabbits

AREA OF STUDY: Musculoskeletal

OBJECTIVES: In title

PROTOCOL: Immobilization and compression of the knee joint was achieved by means of a steel bolt which was placed transarticularly in the sagittal plane at right-angled flexion from the caput of the tibia. Spring pressure from 4 to 24 kp was used as a compressive force; the animals were grouped into low, medium and high spring pressure groups and compared to a 4th group of control rabbits. Immobilization lasted for 14 days, 1, 2, 3 and 6 mo.

IMMOBILIZATION METHOD: Steel bolt

RESULTS: The bony ankylosis of the knee joint was achieved by immobilization and high pressure for periods up to 6 mo. At low pressure and especially with shorter periods of immobilization, bony ankylosis usually did not occur.

SOURCE: Research in Experimental Medicine 157: 223-225, 1972

AUTHOR(S): Weinstein, H. and J.W. Driscoll

EXPERIMENT TITLE: Immobilization-Produced Gastric Pathology in Wild Rats (Rattus norvegicus)

SUBJECTS: Wild rats (Rattus norvegicus)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Preimmobilization food deprivation: 12-96 hr. Immobilization: 0-24 hr in wire-mesh cocoons. Seven experimental conditions (deprivation-immobilization combination), 6 rats per condition: 1) 96 hr deprivation-0 hr immobilization; 2) 84 hr deprivation-12 hr immobilization; 3) 72 hr deprivation-24 hr immobilization; 4) 48 hr deprivation-48 hr immobilization; 5) 48 hr deprivation-24 hr immobilization; 6) 24 hr deprivation-24 hr immobilization; 7) 12 hr deprivation-24 hr immobilization. At the end of the immobilization period, animals were sacrificed and their stomachs removed. Diet: Purina Chow; water ad libitum. Measurements: occurrence, number and severity of gastric lesions.

IMMOBILIZATION METHOD: Wire mesh cocoon

RESULTS: The minimum immobilization period necessary to produce ulcers, given that preimmobilization food deprivation was sufficiently long, seemed to be between 12-24 hr. Wild rats, compared with laboratory rats in other studies, seemed to be more resistant to immobilization-produced gastric pathology.

SOURCE: Physiology and Behavior 9: 39-41, 1972

AUTHOR(S): Welch, B.L. and A.S. Welch

EXPERIMENT TITLE: Differential Activation by Restraint Stress of a Mechanism to Conserve Brain Catecholamines and Serotonin in Mice Differing in Excitability

SUBJECTS: Male white Swiss mice (littermates, 18-20 gm)

AREA OF STUDY: Nervous; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Animals were weaned at 6 wk and housed for 8-12 wk either individually or together in groups of 8. Half of the mice from each housing condition were restrained by taping them to the rounded edge of an inverted cage for 2.5 hr or exactly 7 min. Half of the restrained and half of the non-stressed (free) mice were given initial injections of a biosynthesis inhibitor (α -methyltyrosine); controls injected with vehicle alone. Mice were killed by decapitation and brain tissues were pooled for analysis of norepinephrine, dopamine and serotonin content. Results calculated for restrained and control animals paired according to time of sacrifice.

IMMOBILIZATION METHOD: Adhesive tape and cage

RESULTS: Restraint stress caused greater elevation of brain catecholamines and serotonin in mice kept under 8-12 wk isolation, compared to littermates housed in groups. After inhibition of catecholamine biosynthesis by α -methyltyrosine injection, restraint stress facilitated depletion of norepinephrine and dopamine in pre-isolated mice, but retarded depletion of these amines in group housed mice.

SOURCE: Nature 218: 575-577, 1968

AUTHOR(S): Welch, B.L., D.G. Brown, A.S. Welch, and D.C. Lin

EXPERIMENT TITLE: Isolation, Restrictive Confinement or Crowding of Rats for One Year. I. Weight, Nucleic Acids and Protein of Brain Regions

SUBJECTS: Male CDI rats

AREA OF STUDY: Nervous

OBJECTIVES: In title

PROTOCOL: Five experimental groups: 1) alone (isolated) in large plastic cages (61 x 37 x 23 cm); 2) pairs in large plastic cages; 3) groups of 8-10 rats in large plastic cages; 4) groups of 8-10 rats in similar sized stainless steel wire-mesh cages; 5) alone (isolated) in small 24 x 24 x 21 cm) suspended stainless steel wire-mesh cages. After 1 yr, the rats were decapitated under light ether anesthesia and the brains removed. Measurements: RNA, DNA and protein in the brain; brain weight; body weight; aggressive behavior.

IMMOBILIZATION METHOD: Cage (suspended wire mesh)

RESULTS: Group living per se slightly enlarged the brain; grouped rats had less telencephalon DNA but more RNA than isolated rats and a lower brain protein concentration. Isolated rats living in small cages had telencephalon DNA similar to grouped rats. The relatively low telencephalon DNA of rats under relatively stressful conditions was independent of brain weight.

SOURCE: Brain Research 75(1): 71-84, 1974

AUTHOR(S): Whittaker, D.K. and T.R. Wilson

EXPERIMENT TITLE: The Effect of Age and Strain Differences on the Incidence of Restraint-Induced Oral and Gastric Ulcers in Three Strains of Rats

SUBJECTS: 384 Rats: 64 male, 64 female from each of 3 strains (Sprague-Dawley, Wistar, Hooded Wistar)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Each strain was divided into 4 groups of 16 male and 16 female rats with 8 experimental and 8 control rats per group. Experimental rats were restrained by applying plaster of Paris bandages while under ether anesthesia. Groups from each strain underwent experiments at 2 wk intervals (mean ages 6, 8, 10, 12 wk). Rats sacrificed 24 hr after restraint. Stomachs and heads removed for evaluation of ulcers (gastric and oral).

IMMOBILIZATION METHOD: Plaster of Paris bandages

RESULTS: Both gastric and oral ulcers were found in most of the experimental rats. There were no significant differences between male versus female. Wistar rats showed the highest incidence of gastric ulcers. Gastric ulcers were more prevalent in the youngest rats, except in the Sprague-Dawley strain. The number of oral ulcers was small as compared with the incidence of gastric ulceration, and was only significantly more than the control level in the Sprague-Dawley strain.

SOURCE: Journal of Dental Research 51(2): 619-625, 1972

AUTHOR(S): Whittow, G.C., P.D. Sturkie, and G. Stein, Jr.

EXPERIMENT TITLE: Cardiovascular Changes in Restrained Chickens

SUBJECTS: White Leghorn chickens

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls, 6 unrestrained roosters; 2) experimental, 6 roosters, 6 hens restrained on their backs for 3 hr. Measurements: changes in rectal temperature, respiratory rate, cardiac output, blood pressure, heart rate, arterial hematocrit, and total peripheral resistance.

IMMOBILIZATION METHOD: Not stated

RESULTS: Restraint over 2-3 hr caused an increase in cardiac output, heart rate and stroke volume and a decrease in blood pressure, peripheral resistance and hematocrit. These cardiovascular responses cannot be attributed to concurrent changes in body temperature or in respiratory rate because significant differences in rectal temperature and respiratory rate did not occur.

SOURCE: Poultry Science 44(6): 1452-1459, 1965

AUTHOR(S): Williams, P.E. and G. Goldspink

EXPERIMENT TITLE: The Effect of Immobilization on the Longitudinal Growth of Striated Muscle Fibres

SUBJECTS: Male heterozygous 129/Re mice

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Plaster casts were applied to 1 hind limb of mice anesthetized with ip injections of Nembutal. The casts held the whole hind limb in extended position or in the flexed position. The contralateral leg served as the control. Casts were changed weekly. ³H adenosine was injected following immobilization to label the sarcomeres. Both young (4 gm) and adult (28-30 gm) mice were investigated in this experiment. Diet: Pillsbury's special breeding diet and water. Measurements: sarcomeres in fibers.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: Immobilization in the shortened position resulted in a decrease in the postnatal addition of sarcomeres in young muscles and sarcomere loss in adult muscles. Both sarcomere numbers returned to normal following restriction. In the lengthened position, immobilization resulted in a decrease in the postnatal addition of sarcomeres in very young muscles, but an increase in muscles in mice over 2 1/2 wk old. Ability to recover from immobilization was not affected by the length of restraint or by the animal's stage of development during recovery. ³H adenosine injection indicated that muscle fibers were adding sarcomeres mainly at their ends. Immobilization of young muscles resulted in a reduction of the postnatal increase in muscle fiber nuclei; restraint removal increased the number. Following tenotomy of the gastrocnemius, there was an increased number of sarcomeres in the soleus muscle fibers.

SOURCE: Journal of Anatomy 116(1): 45-55, 1973

AUTHOR(S): Wilson, T.R.

EXPERIMENT TITLE: Strain and Sex Differences in Gastric Ulceration in Restrained Rats

SUBJECTS: Male and female Wistar, Hooded Wistar, and Sprague-Dawley rats

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: All rats were deprived of food 24 hr prior to experiment, with water allowed. Rats in experimental groups (male and female subgroups for each strain) were anesthetized with ether and both hind legs were immobilized in plaster of Paris bandages; movement of front legs not restricted. Controls subject to same conditions without restraint. After 24-hr restraint, rats were killed with ether and stomachs removed for assessment of gastric ulceration. Measurements: classification and scoring of ulcers in terms of size and number of ulcers.

IMMOBILIZATION METHOD: Plaster of Paris bandages

RESULTS: Differences in ulcer severity were observed between the 3 strains of rats. For Wistar rats, ulcer severity is highly significant for both males and females ($p < 0.001$); for Hooded Wistar rats, ulcer severity is highly significant for females ($p < 0.001$) but slightly less so for males ($p < 0.01$). For Sprague-Dawley rats, ulceration was not significantly greater between experimental and control groups of either sex.

SOURCE: Acta Geneticae Medicae et Gemellologiae 16(3): 310-316, 1967

AUTHOR(S): Winters, W.D.

EXPERIMENT TITLE: Various Hormone Changes During Simulated Space Stresses
in the Monkey

SUBJECTS: 4 Male Macacca nemestrina monkeys (4.5-5.5 kg)

AREA OF STUDY: Endocrine; Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: At 2 week intervals the animals were subjected to a simulated launch profile which included centrifugation at 7 G. After this procedure, the animals were restrained to a couch in a second attenuated, light proof isolation room for 2 wks, at the end of the 2 wk isolation, they were subjected to a re-entry profile (from start to 10 G in 1 min, deceleration to 5 G for 30 sec to stop in 1 min). On 2 occasions, vibration studies were performed on the animals. During each phase of experimentation the urine was collected and analyzed. Measurements: 17-ketogenic steroid and catecholamine content, urine volume.

IMMOBILIZATION METHOD: Couch

RESULTS: A reduction in urine volume was observed in all instances. A fall in steroid and slight elevation in catecholamine excretion was observed following vibration and centrifugation. The centrifugation was slightly more stressful. Isolation with restraint was a severe stress as demonstrated by a marked elevation of amine, and a marked reduction in both urine output and steroid excretion.

SOURCE: Journal of Applied Physiology 18: 1167-1170, 1963.

AUTHOR(S): Woodward, A.H. and J. Jowsey

EXPERIMENT TITLE: The Effect of Glucagon on Immobilization Osteoporosis
in Rats

SUBJECTS: 25 Male Sprague-Dawley rats (200-250 gm)

AREA OF STUDY: Skeletal; Endocrine

OBJECTIVES: In title

PROTOCOL: The patellar tendon, patellar retinacula, and tendo calcaneus were excised from one hind limb; the other intact limb served as a control. 12 rats were given 0.03 mg glucagon in 0.1 ml of saline sc twice daily; remaining rats were given 0.01 ml of saline sc. After 14 days, blood was drawn by cardiac puncture, and the rats were killed. Femurs and tibiofibulas were removed for preparation and analysis. Measurements: bone weights and calcium content; blood serum calcium and phosphate concentrations; body weight.

IMMOBILIZATION METHOD: Tenotomy

RESULTS: The weight of the dried and of the ashed femurs and tibiofibulas from the immobilized limbs was consistently lower than those from the intact side. Glucagon had no effect on the development of osteoporosis in the immobilized limb, but did produce significantly increased femoral weight in both the immobilized and the intact hind limbs. The serum phosphate concentration was significantly lower in rats receiving glucagon, compared to the control animals. Serum calcium concentration was similar in both groups. Body weight increased in glucagon-treated rats as well as in controls, with no significant differences between the two groups.

SOURCE: Endocrinology 90(5): 1399-1401, 1972

AUTHOR(S): Wray, J.B.

EXPERIMENT TITLE: Glucose Uptake by Fractured and Immobilized Limbs
in the Dog

SUBJECTS: 25 Male mongrel dogs (10-18 kg)

AREA OF STUDY: Muscular; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Three groups: 1) 5 controls; 2) 11 dogs subjected to a closed fracture of one tibia, right and left tibias were alternately fractured and immediately immobilized in plaster casts; 3) 9 dogs subjected to immobilization of alternate lower extremities in plaster casts without fracture. Studies were carried out 5 and 15 days after cast application. After anesthesia had been induced, each animal was tied down to an experimental table in the supine position. A forelimb vein was cannulated and an iv drip of 5% glucose in water was started. This infusion was thereafter continued at the rate of 30 drops/min. Two series of blood samples and flow measurements were carried out in each animal. After the last sample the animal was sacrificed by an overdose of pentobarbital. Measurements: blood pressure; blood sugar; uptake of glucose.

IMMOBILIZATION METHOD: Plaster cast

RESULTS: Limbs immobilized for 5 and 15 days utilized less glucose than their paired opposite members. Fracture and cast immobilization of an extremity resulted in a decreased uptake of glucose by the involved limb as compared to the normal opposite member. Casted animals showed a more marked reduction in glucose uptake than the fractured group.

SOURCE: Surgery, Gynecology and Obstetrics 120(1): 45-48, 1965

AUTHOR(S): Yamaji, K. and H. Sato

EXPERIMENT TITLE: Studies on Fatigue-Time Curve of Pathological Skeletal Muscle

SUBJECTS: Adult white rabbits (2-2.5 kg)

AREA OF STUDY: Muscular

OBJECTIVES: In title

PROTOCOL: Four groups: 1) controls; 2) circulation occluded - the femoral vessels of the rabbits were tied to occlude circulation to the muscle; 3) immobilization - the knee and ankle joints of the rabbits were immobilized in a plaster cast for 33 days; 4) denervation - the sciatic nerve was removed 12 days prior to stimulation. For each group the fatigue-time curve of the gastrocnemius et solus muscle was determined by stimulating the muscle and/or nerve with electric shocks.

IMMOBILIZATION METHOD: Plaster cast; Denervation

RESULTS: No reduction of active tension was observed in normal muscle when it was stimulated with 1 c/s repeated electric shock. Fast decay of isometric tension was noticed as stimulating frequencies were increased. Rapid decrease of active tension was recorded in the circulatory occluded muscle from immediately after the occlusion of blood flow. The muscle immobilized for 33 days showed sharp reduction of active tension both in magnitude and rate of decay of active tension due to the repeated stimulus as compared with those of control. Muscle denervated for 12 days showed the same tendency to a lesser degree. Stair case phenomenon was observed only in normal muscle.

SOURCE: Nagoya Medical Journal 10(1): 1-10, 1964

AUTHOR(S): Yamori, Y., M. Matsumoto, H. Yamabe, and K. Okamoto

EXPERIMENT TITLE: Augmentation of Spontaneous Hypertension by Chronic Stress in Rats

SUBJECTS: Spontaneously Hypertensive, Normotensive Wistar rats

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Three Series: I - Immobilization, in 9 experiments, Normotensive Wistar (NR) and Spontaneously Hypertensive (SHR) rats were restrained on boards for 2-10 hr daily for 20-30 days. The boards were devised to support the rat in a supine position by their paws with strings and to fix their neck in collars. Nonimmobilized SHR and NR served as controls. Series II - NR and SHR groups were placed in "stress" cages and exposed to randomly combined visual (flickering bulb), auditory (buzzer) and electric (floor shock) stimuli for 1-4 hr daily from the age of 40 days to 18 wk. Unstressed rats served as controls. Series III - Chronic cold exposure, 3 mo old SHR and NR rats were housed 1 or 2 per cage in a 2-10°C cold room for 7 wk. Controls were kept at normal temperatures. Measurements: blood pressure, autopsy.

IMMOBILIZATION METHOD: Board

RESULTS: Immobilized SHR had a highly significant increase in blood pressure in comparison to control SHR or control NR and maintained at even 1 mo after final stress, while a slight elevation was observed only at the end of stress in male NR. In immobilized SHR, 8% developed severe hypertension; autopsy revealed cerebral and abdominal hemorrhage, retinal bleeding and nephrosclerosis. Auditory, visual and electric shock stressed NR had a significantly higher blood pressure than control NR after the 6th wk; the rise in blood pressure in SHR was significantly higher than in control SHR. In the 3rd and 7th wk of cold exposure, SHR showed significantly higher blood pressure than control SHR while no difference was noted between cold exposed NR and control NR.

SOURCE: Japanese Circulation Journal 33: 399-409, 1969

AUTHOR(S): Yanase, M.

EXPERIMENT TITLE: A Study on the Role of the Brain in the Establishment of Adaptation to Repeated Immobilization Stress. Part 1: Changes in Brain Activity and Bodily Functions Under Repeated Immobilization Stress

SUBJECTS: 112 Female New Zealand rabbits (2.8-3.5 kg)

AREA OF STUDY: Metabolism and Energy Exchange; Nervous

OBJECTIVES: In title

PROTOCOL: Two Series: I - Rabbits were placed in a supine position and their limbs tied down for 6 hr daily for 7 days. Groups: 1) rectal temperature taken at intervals 3 hr before, during and 2 hr after stress; 2) administered methacholine chloride im, 3 days before, 5 hr after 1st stress and during 7th stress; 3) administered glucose iv 3 days before and on the 4th hr of the 1st and 7th stress; II - 4 groups: 1) controls; 2) 1 stress only; 3) 6 consecutive stresses; 4) 7 stresses. In 40 rabbits, electrodes were implanted to measure brain activity during repeated immobilization. Diet: artificial feed (RC-5) and water. Measurements: food and water intake; glucose tolerance; EKG; EEG; rectal temperature; metabolism of glucose and low-grade fatty acids in liver slices.

IMMOBILIZATION METHOD: Tied down in supine position

RESULTS: Decrease in food and water intake and urine volume in early stages were reversed after repeated immobilizations. The 1st immobilization caused decreases in rectal temperature, glucose tolerance, oxidation of glucose and short chain fatty acids in liver slices and changed the response of the heart rate to mecholyl; the 7th immobilization had little effect on these. The threshold of stimulation in the midbrain reticular formation inducing neocortical EEG arousal decreased under immobilization; and that in the dorsomedial nucleus of the thalamus increased. Changes in multiple unit activity in the ventromedial nucleus, anterior hypothalamic area, preoptic area and hippocampus under the 1st immobilization stress diminished with repeated immobilizations.

SOURCE: Journal of the Japanese Physiological Society 35: 109-124, 1973

AUTHOR(S): Yano, S., M. Yamamoto, and M. Harada

EXPERIMENT TITLE: Variation in Serum Glucose, Serum Free Fatty Acids, and Liver Glycogen Concentrations and Development of Gastric Erosions in Mice Subjected to Stress

SUBJECTS: Male ddys strain mice (19-21 gm)

AREA OF STUDY: Metabolism and Energy Exchange; Digestive

OBJECTIVES: In title

PROTOCOL: Experimental mice were immobilized in stress cages and immersed in water baths of 25° to the depth of the xiphoid. Three groups: 1) short term experiment - mice were deprived of food at 10 a.m., subjected to stress at 7 a.m. on the next day and sacrificed at 1, 2 and 3 hr after stress; 2) long term experiment - mice were deprived of food at 10 a.m., subjected to stress at 4 p.m. on the same day and sacrificed at 3, 6, 12 and 18 hr after stress; 3) controls - fasted as in group 1 and 2. Measurements: serum glucose concentration; FFA concentration; liver glycogen content; severity of gastric erosions.

IMMOBILIZATION METHOD: Cage (stress)

RESULTS: Short-term experiment: serum glucose concentration decreased 1 hr after stress; this level was sustained for 2 hr. FFA concentration increased and remained so 3 hr after stress. Liver glycogen content decreased to extreme low levels and gastric erosions were generated 1 hr after stress. Long-term experiment: serum glucose concentration decreased 3 hr after stress and progressively increased thereafter. A significant increase in FFA concentration was observed 3 hr after stress. Liver glycogen content was almost exhausted and these levels were maintained during the next 6 hr period. The highest incidence of gastric erosions developed 18 hr after stress.

SOURCE: Chemical and Pharmaceutical Bulletin 24(7): 1646-1656, 1976

AUTHOR(S): Yaremenko, B.R.

EXPERIMENT TITLE: Influence of Prolonged Hypodynamia on Certain Physiological Functions in Dogs

SUBJECTS: 20 Male dogs (12-24 kg)

AREA OF STUDY: Behavior; Circulatory

OBJECTIVES: In title

PROTOCOL: The carotid arteries of the dogs had previously been brought out in fistulas. After the wounds from the operation had healed completely, the animals were placed in a Pavlov stand to record the arterial pressure from the left carotid artery and then placed in specially designed stands which severely limited their motor activity. Measurements made every 7 days: general behavior; body weight; body temperature; arterial pressure and pressor sinocarotid reflex in response to compression of the second carotid artery; total plasma cholinesterase activity.

IMMOBILIZATION METHOD: Stand

RESULTS: By the 7th day of hypodynamia, the dogs could be divided into 2 groups on the basis of their behavior: one group (12 dogs) retained its activity; the other (8 dogs) was passive and inactive. By the end of the 3rd wk of hypodynamia, dogs in the passive group were unable to move under their own power and showed pronounced trophic disturbances; the active dogs showed no such trophic disturbances. During the course of hypodynamia the arterial pressure rose while the level of the pressor sinocarotid reflex decreased. The body weight fell by 17% on the average and the body temperature did not change significantly.

SOURCE: Patologicheskaya Fiziologiya i Eksperimentalnaya Terapiya
14: 10-13, 1970

AUTHOR(S): Yaremenko, B.R.

EXPERIMENT TITLE: The Course of Traumatic Shock in Dogs Sustaining Prolonged Hypodynamia

SUBJECTS: 31 Female dogs (13-24 kg)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Three groups: 1) hypodynamia for 14 days - 10 dogs; 2) hypodynamia for 28 days - 8 dogs; 3) intact controls - 13 dogs. After hypodynamia, the animals were subjected to shock-inducing trauma by crushing the soft tissues of the thigh. Measurements: arterial pressure from the central end of the right femoral artery, respiration, sinocarotid pressor reflexes, survival time over 6 hr observation.

IMMOBILIZATION METHOD: Special stall

RESULTS: The arterial pressure level in dogs sustaining hypodynamia was higher than controls. The respiration rate of group 2 was considerably less than group 1 or controls. After infliction of trauma, the sinocarotid pressor reflexes disappeared or underwent phase changes, arterial pressure decreased and marked tachycardia and curtailment of respiration were observed. Considerably less trauma had to be applied to group 2 to reproduce shock. Survival time in state of shock was significantly less for groups 1 and 2 than controls.

SOURCE: Patologicheskaya Fiziologiya: Eksperimentalnaya Terapiya
15: 83-84, March-April 1971

AUTHOR(S): Yaremenk., B.R.

EXPERIMENT TITLE: Reactivity of the Cardiovascular System in Dogs in Traumatic Shock After Prolonged Hypodynamia

SUBJECTS: Male dogs (13-24 kg)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Hypodynamia was induced by keeping the dogs in special frames which severely restricted movement. 3 groups: 1) 14-day hypodynamia, 10 dogs; 2) 28-day hypodynamia, 8 dogs; and 3) controls, 13 dogs. After termination of hypodynamia, shock-producing trauma was inflicted by crushing the soft tissues of the thigh until the defensive response ceased, the animals' general condition became severely disturbed, and the blood pressure fell to 60-65 mm. Animals were observed for 6 hr after infliction of trauma. Measurements: respiration and arterial pressure; magnitude of the carotid sinus pressor reflexes in response to compression of the common carotid artery for 5 and 10 sec; survival duration; mean number of blows necessary to produce shock; effectiveness of administration of Petrov's blood substitute.

IMMOBILIZATION METHOD: Special frame

RESULTS: The mean level of the arterial pressure in the dogs exposed to hypodynamia was slightly higher than in controls; the respiration rate was considerably lower after 28-day hypodynamia than in the other groups. After trauma, the transient excitation which the animal developed was followed by a serious general condition; the carotid sinus pressor reflexes disappeared or became phasic in character; the arterial pressure fell; marked tachycardia was observed; and in most cases the respiration rate was slowed. Third-order waves appeared on the arterial pressure curve after trauma; as the shock increased the waves became deeper, and 30-40 min before the animals' death they disappeared. The mean number of blows necessary to produce shock in the dogs after 28-day hypodynamia was 87 ± 9 , control 140 ± 16 , and 14-day hypodynamia 175 ± 24 blows. As a rule the hypodynamia animals died 60-90 min after trauma; the period of survival in a state of shock was significantly longer in the control dogs. In dogs after hypodynamia, more profound disturbances of reflex regulation of the circulation from the carotid sinus zone than in the control series were found. To raise and stabilize the arterial pressure of the dogs in the control series of experiments, a much smaller volume of blood substitute had to be injected than in the hypodynamic groups.

SOURCE: Bulletin of Experimental Biology and Medicine 72(9): 1002-1004, 1971

AUTHOR(S): Yau, W.M.W., M.F. Nudd, and G.H. Gass

EXPERIMENT TITLE: Chronic Restraint and Glycine, Phenylalanine and Oleic Acid Absorption

SUBJECT: Male rats (Rattus norvegicus)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) housed in restraint cages for 5-25 wk. Diet: ^{14}C -labeled nutrient (220 mg/ml glycine, 220 mg/ml phenylalanine, 1594 $\mu\text{mole/ml}$ oleic acid). Measurement: nutrient absorption.

IMMOBILIZATION METHOD: Cage

RESULTS: Restraint produced different absorptive patterns for the 3 nutrients throughout testing, but there was no deviation from normal except at the 5th wk interval when restraint produced a significantly greater uptake of phenylalanine.

SOURCE: Comparative Biochemistry and Physiology. A. Comparative Physiology 39: 545-547, 1971

AUTHOR(S): Yegorov, B.B., V.I. Lobachik, and L.N. Kleymenova

EXPERIMENT TITLE: Changes in Calcium Metabolism in Rats During Hypokinesia

SUBJECTS: 250 White male rats (180-200 gm)

AREA OF STUDY: Skeletal; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Animals were exposed to hypokinesia for 30 and 60 days by placing them in specially designed cages. At the end of the hypokinesia period, the animals were injected ip with $^{45}\text{CaCl}_2$ at the rate of $0.05 \mu\text{g}/\text{gm}$ wt. The animals were killed by decapitation 1/2, 1, 3, 6 and 12 hr and 1, 2, 5 and 10 days after injection. Proximal epiphysis and diaphysis of the femural and parietal bones were extracted for analysis; radioactivity was determined.

IMMOBILIZATION METHOD: Cage

RESULTS: A significant decrease in ^{45}Ca incorporation into the bone tissue of restrained animals was noted. It reached the maximum value in the epiphyseal parts of the femur bones. The rate of ^{45}Ca elimination from the bone tissue of the test animals was greater than in the controls.

SOURCE: Space Biology and Medicine 3(1): 85-91, 1969

AUTHOR(S): Yegorov, B.B. and R.I. Gritsyuk

EXPERIMENT TITLE: Influence of Orotic Acid on the Weight Dynamics of Rats During Restricted Motor Activity

SUBJECTS: 100 Common white male rats (100 gm)

AREA OF STUDY: Blood; Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: Four groups: 1) unrestrained movement (control); 2) unrestrained movement and daily administration of 0.1 gm/kg orotic acid; 3) hypokinesia; 4) hypokinesia and daily administration of 0.1 gm/kg orotic acid. Hypokinesia was achieved by placing the rats in individual plastic cages; the root of the tail fixed. All rats were decapitated on the 30th day of the experiment. Diet: standard. Measurements: consumed food; water consumption; regime and volume of diuresis; weight; hemogram of peripheral blood; electrolyte composition of the blood and urine.

IMMOBILIZATION METHOD: Cage (plastic)

RESULTS: In the first day, experimental rats increased their motor activity by trying to escape from the cages; there was a decrease in food excitability. Group 1 and 2 rats showed a progressive increase in weight; however, the weight increments of group 2 vs group 1 rats was insignificant. Group 4 rats showed a weight increase of 10% above the initial levels, and by 20% vs group 3 rats. There was no direct relationship between the weight increase and decrease in moisture loss and increase in fluid consumption. Peripheral blood by day 30 for all rats remained within limits for biological species.

SOURCE: Space Biology and Medicine 10(5): 117-120, 1976

AUTHOR(S): Yegorova, V.V. and V.G. Gredin

EXPERIMENT TITLE: Effect of Immobilization Stress on Regulatory Characteristics of Certain Enzymes Involved in Membrane Digestion

SUBJECTS: 48 Albino male Wistar rats (200 gm)

AREA OF STUDY: Digestive

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 24 hr immobilization stress in cage after 18-20 hr fast; 2) controls - nonstressed. Measurements: after 4, 24, 48, 72 or 168 hr, α -amylase activity determined from homogenates of proximal segment of mucus small intestine; pH function of α -amylase.

IMMOBILIZATION METHOD: Cage

RESULTS: The greatest reduction in α -amylase activity was observed in 24 hr after stress, returning to the initial level in 7 days. A trend was observed towards an increase in the inhibitory effects of tributyrin, the most significant increase occurring 24 hr after immobilization stress.

SOURCE: Doklady Akademii Nauk SSSR 227(5): 1264-1267, 1976

AUTHOR(S): Young, D.R. and J.W. Tremor

EXPERIMENT TITLE: Effects of Hypodynamic Simulations on the Skeletal System of Monkeys

SUBJECTS: Adult male monkeys (Macaca nemestrina)

AREA OF STUDY: Skeletal; Fluid and Electrolyte

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypodynamic and hypogravic environments simulated for 10 wk or 10-24 wk in a semirecumbent position in a primate holding facility. Diet: Purina chow and water. Measurements: total body calcium by photon absorption technique; skeletal resorption rate; bone stiffness; food and water consumption; body weight; nitrogen and mineral metabolism; urinary excretion; urinary nitrogen and potassium; blood volume.

IMMOBILIZATION METHOD: Primate holding facility

RESULTS: During the first 2-3 wk of restraint, food intake was depressed but then returned to normal values. Water consumption declined during restraint. Body weight was reasonably constant during the control phase of testing; variations of 6-12% in body weight were measured during restraint. Urinary excretion was higher and more variable in the restrained monkeys; urinary nitrogen and potassium were significantly higher and phosphorus excretion increased 3.8 times. After 1 mo of restraint, total blood volume decreased 11.7% and red cell mass decreased 12%. Bone mineral content of the midshaft of the tibia decreased 3.5% over 1 mo restraint; the ulna and distal radius was unchanged. In 24 wk restraint, the overall calcium turnover rate was 53% increased, urinary calcium was modestly elevated, urinary phosphate increased 8 times, urinary hydroxyproline was doubled. A system for measuring bone mineral content by a high-intensity source of ¹⁵³gadolinium was described. Bone resorption studies showed a calcium turnover after 2 wk of 50% from skeletal resorption and 50% from dietary absorption. Methods for measuring bone bending rigidity and holding, transporter and surgical workbench facilities for primate experiments are described.

SOURCE: Space Simulation, Proceedings of the 9th Conference, Los Angeles, California, April 26-28, 1977, National Aeronautics and Space Administration, Washington, D.C., 1977, pp. 123-140. (NASA CP-2007)

AUTHOR(S): YoungLai, E.V. and P. Dimond

EXPERIMENT TITLE: Immobilization Does Not Inhibit the Post-Coital
Ovulatory Surge of Luteinizing Hormone in the
Rabbit

SUBJECTS: 12 Mature female New Zealand white rabbits

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Following im injection of 50 µg/kg estradiol benzoate in propylene glycol for 2 days, rabbits were cannulated, allowed to recover, and then mated with a proven buck. Following mating, the female was removed, a blood sample drawn and either 1) immobilized completely in a cage for 3-5 hr; or 2) allowed to move between sampling times. The next day, the rabbit was laparotomized and the number of corpora lutea were noted. Measurements: luteinizing hormone (LH); progesterone; 20α-hydroxypregn-4en-3-one.

IMMOBILIZATION METHOD: Cage

RESULTS: Immobilization did not inhibit ovulation or the preovulatory surge of LH in either group of rabbits.

SOURCE: Neuroendocrinology 20: 352-357, 1976

AUTHOR(S): Yurgens, I.L. and O.I. Kirillov

EXPERIMENT TITLE: Mitotic Activity of Adrenal Cortical Cells in Rats
During Prolonged Hypokinesia

SUBJECTS: Male Wistar rats (95-100 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control rats; 2) experimental rats were placed in small transparent plastic containers which restricted their movements. All rats were sacrificed in groups of 5-13 at 1 and 12 hr and 2, 5, 9, 14 and 19 days after the beginning of the experiment. Measurements: weight of adrenals, number of mitosis for each zone.

IMMOBILIZATION METHOD: Container (transparent plastic)

RESULTS: The weight of the adrenals was increased in rats exposed to hypokinesia. Mitotic division in the adrenal cortex was sharply inhibited after 1 hr; the index in the zona glomerulosa returned to normal at 12 hr to 9 days, but was considerably higher in the outer zona fasciculata than in controls. At 14 and 19 days, when rats were exhausted and adrenal hypertrophy was less marked, the mitotic index in both zones was reduced.

SOURCE: Bulletin of Experimental Biology and Medicine 74(7): 837-839, 1972

AUTHOR(S): Yurgens, I.L. and O.I. Kirillov

EXPERIMENT TITLE: Morphological Changes in the Suprarenals of Rats
During Hypokinesia

SUBJECTS: Male Wistar rats (95-100 gm)

AREA OF STUDY: Endocrine

OBJECTIVES: In title

PROTOCOL: Two groups: 1) control rats; 2) experimental rats were placed in boxes. 5-9 rats from each group were killed 12 hr, 2, 5, 9, 14 and 19 days later. Measurements: body weight; weight and area of suprarenals; volume of cell nuclei.

IMMOBILIZATION METHOD: Box

RESULTS: In the immobilized rats from the very onset of the experiment there was a decrease in body weight. The weight of the suprarenals increased due to an enlargement of the fascicular zone. At later experimental times hypertrophy of the suprarenals decreased whereas dystrophy developed. The size of the nuclei increased in all zones in the experimental rats. This was very distinct in animals killed 12 hr and 2 days after the beginning of the experiment. As dystrophy increased, hypertrophy of the nuclei decreased, the dropoff being greater in the inner than in the outer parts.

SOURCE: Space Biology and Medicine 6(4): 1-6, 1972

AUTHOR(S): Zemjanis, R., B. Gondos, W.R. Adey, and A.T.K. Cockett

EXPERIMENT TITLE: Testicular Degeneration in Macaca nemestrina Monkeys
Used in Pre-space Flight Tests

SUBJECTS: 8 Macaca nemestrina monkeys

AREA OF STUDY: Endocrine; Reproduction

OBJECTIVES: In title

PROTOCOL: Prior to pre-space flight tests, all monkeys underwent neuro-physiologic studies, including periodic immobilization. Intracranial electrodes were implanted at least 60 days prior to tests; a permanent urethral catheter was placed in all monkeys 8 to 12 days prior to tests, at which time an initial testicular biopsy was taken. Operated monkeys were immobilized in a special capsule couch for the duration of the tests, 6-42 days. Control monkeys were confined in a simulated capsule. Pre-space flight tests: 1) vibration; 2) endurance; 3) thermo vac; and 4) walk through. Testicular tissue specimens were obtained by biopsy. Measurements: spermatogenic activity; changes in testicular state; seminiferous tubules; spermatocytes.

IMMOBILIZATION METHOD: Couch

RESULTS: Normal spermatogenesis was observed in all of the pre-test specimens, except for one taken from an animal with juvenile testes. One animal involved in the test for only seven days had a normal terminal specimen. Severe testicular degeneration developed in the six remaining animals, all of whom were kept under test conditions for 14 days or more. Seminiferous tubules were generally lined by a single to double layer of Sertoli cells and scattered spermatogonia, mainly type A. Spermatocytes were rare and no spermatozoa were seen. The changes involved all of the tubules in a uniform manner.

SOURCE: Aerospace Medicine 40: 1316-1322, 1969

AUTHOR(S): Zemjanis, R., B. Gondos, W.R. Adey, and A.T.K. Cockett

EXPERIMENT TITLE: Testicular Degeneration in Macaca nemestrina Induced by Immobilization

SUBJECTS: 4 Macaca nemestrina monkeys

AREA OF STUDY: Endocrine; Reproduction

OBJECTIVES: In title

PROTOCOL: All four monkeys had been exposed to restraint previously. For this experiment they were placed in specially designed NASA suits and suspended in couch-like frames. The monkeys were in an upright sitting position during the daytime and a nearly horizontal resting position at night. After 14 days immobilization the primates were released and returned to cages. Testicular specimens were obtained prior to and after 7, 10 and 14 days of immobilization, and 30 and 60 days after release from couch. Initially, biopsies were taken from the cranial surface of the right testis, then from alternate testes and their surfaces. Diet: fresh fruits, vegetables, nuts, bread, monkey pellets ad libitum once a day; water several times a day.

IMMOBILIZATION METHOD: Specially designed NASA suits and couch-like frames

RESULTS: Initial biopsies were morphologically normal. At 7 days, some testicular degeneration had occurred. At 10 days, uniform pathologic alterations were present and more advanced than at 7 days. At 14 days, severe, generalized testicular degeneration occurred in 3 monkeys, with less extensive destruction of the seminiferous epithelium in the 4th monkey; only Sertoli cells and spermatogonia A lined the seminiferous tubules. 30 days following release, spermatogenesis was apparent; recovery was complete after 60 days.

SOURCE: Fertility and Sterility 21(4): 335-340, 1970

AUTHOR(S): Zimin, Yu.I.

EXPERIMENT TITLE: Emigration of Cells From the Spleen Under Normal Conditions and in Stress

SUBJECTS: 156 Wistar rats, 10 wk old (160-180 gm)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Three groups: 1) controls; 2) rats stressed by electrical stimulation of series of pulses totaling 3 sec duration, interval between series: 1.5 min; current: 2.5 mA; frequency: 2000 Hz; duration of stimulation: 3 hr; 3) rats immobilized for 6 hr on their backs. The rats were decapitated, and their spleens were isolated. Measurements: number of cells in the spleen; changes in mitotic index (in promille) in the spleen.

IMMOBILIZATION METHOD: Not stated

RESULTS: Electrical stimulation and immobilization led to a marked decrease in the number of cells in the spleen. The mitotic activity of the spleen cells also was reduced 3-6 hr after the beginning of exposure to both procedures. The decrease in the number of spleen cells after both procedures was caused 90% by increased emigration and 10% by decreased formation of new lymphocytes.

SOURCE: Bulletin of Experimental Biology and Medicine 71(6): 615-616, 1971

AUTHOR(S): Zorya, L.V.

EXPERIMENT TITLE: Changes in Gas Exchange, Tissue Respiration and Glycolysis in Rats During Hypokinesia

SUBJECTS: 233 Rats (130-180 gm)

AREA OF STUDY: Respiratory; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Two groups: 1) controls; 2) hypokinetic in small individual cages. Measurements: oxygen consumption; tissue respiration and glycolysis in the myocardium, skeletal muscle and the liver on days 4, 8, 16 and 30.

IMMOBILIZATION METHOD: Cage

RESULTS: The effect of hypokinesia during the initial period was expressed most clearly in the changes of general gas exchange and in the intensity of liver and myocardial tissue respiration. In skeletal muscle a lowering in the intensity of tissue respiration was detected only on day 30. Lowered glycolysis was observed in this tissue much earlier, beginning on day 8 of hypokinesia.

SOURCE: Fiziologicheskii Zhurnal 22(3): 414-417, 1976

AUTHOR(S): Zorya, L.V.

EXPERIMENT TITLE: Effect of Seduxen on the Course of Experimental Hypokinesia

SUBJECTS: 227 Male/female white mongrel rats (130-180 gm)

AREA OF STUDY: Pharmacology; Metabolism and Energy Exchange

OBJECTIVES: In title

PROTOCOL: Restraint: 16 days in metal mesh cages. Five series of experiments: Series 1) no seduxen (65 rats); Series 2) seduxen per os, once a day, 5 mg/kg (20 rats); Series 3) seduxen ip once a day, 5 mg/kg (97 rats); Series 4) seduxen per os, 3 times a day, daily dosage of 15 mg/kg (10 rats); Series 5a) seduxen hypodermically twice a day, dosage of 10 mg/kg (10 rats), 5b) seduxen given for 8 experimental days, without removing subjects from cages. Diet: bread, milk, grain, water. Measurements: weight dynamics; mortality; EKG findings; succinate dehydrogenase activity; glycolytic processes and tissular respiration in skeletal muscle, liver and myocardium of 1st and 3rd series only, on the 4th, 8th and 16th hypokinetic days.

IMMOBILIZATION METHOD: Cage (metal mesh)

RESULTS: Weight loss occurred in all series of experiments during the course of hypokinesia. Mortality did not diminish with administration of seduxen: 31% of animals in the 1st series died with the first 16 days of hypokinesia; 33% died in series 5b. Type of administration did not appreciably affect mortality. Glycolytic processes increased sharply in skeletal muscle in the 3rd series, consistently declined in the 1st series. Tissular processes declined sharply in skeletal muscle in the 3rd series, less markedly in the 1st series. Glycolytic levels in liver and myocardium declined in both groups. There was a significant increase in activity of succinate dehydrogenase in muscle tissue of the 1st and 3rd series. EKG: increased amplitude of T wave during all hypokinesia; signs of marked, diffuse changes in the myocardium of animals in the 3rd series were not removed by seduxen. Marked bradycardia developed under the influence of seduxen in hypokinetic animals throughout the period of investigation; tachycardia was observed in animals not given seduxen. Cause of death was most frequently a change in the lungs (87.5%).

SOURCE: Space Biology and Aerospace Medicine 11(6): 90-97, 1977

AUTHOR(S): Zotova, N.I.

EXPERIMENT TITLE: Effect of Hypokinesia on the Telencephalic Blood Vessels of Rabbits

SUBJECTS: 35 Rabbits

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) hypokinesia in close cages for 1, 2, 3, 4, 6, 8, 12 and 16 wk, 33 rabbits; 2) controls, 4 rabbits. Measurements: histology of the blood vessels in the brain, total area of vessels.

IMMOBILIZATION METHOD: Cage (close)

RESULTS: After 4-6 wk, the majority of radial arteries and veins were drastically constricted and the capillary network was nonuniform. After 12 wk the radial vessels were drastically deformed and the pattern of the capillary network was strongly altered. The data obtained on the basis of the method of injection of the cerebral blood vessels were confirmed by histological study.

SOURCE: Arkhiv Anatomii, Gistologii i Embriologii 73(10): 49-55, 1977

AUTHOR(S): Zyss, R., J. Krol, and E. Kus

EXPERIMENT TITLE: Effect of Long-Standing Immobilization on Myocardial Metabolism in Guinea Pigs

SUBJECTS: 210 Guinea pigs (195 gm)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 80 control guinea pigs; 2) 130 experimental. The experimental animals were immobilized for 6 mo by placing them in metal cages. The control animals were kept in groups of 5 in large pens. During the experiment all animals were kept in a room at 18-21°C, relative humidity 30±10% and natural lighting. For biochemical investigations weighed sections of left-ventricular myocardium were frozen three times in liquid nitrogen and defrozen for destroying cellular structures, and were homogenized. In the homogenates the contents of the following substrates, electrolytes, and enzymes were determined: nucleic acids - RNA and DNA; glycogen; lactic acid; fatty acids; electrolytes - sodium, potassium and calcium; succinic dehydrogenase; lactic dehydrogenase; adenosine triphosphatase. Diet: food and water ad libitum.

IMMOBILIZATION METHOD: Cage (metal)

RESULTS: Quantitative differences were found between immobilized animals and control: lower level of nucleic acids and glycogen, higher level of lactic acid and fatty acid, higher content of sodium and calcium, decreased K/Na and K/Ca ratios, lower activity of succinic dehydrogenase and ATP-ase, and higher activity of lactic dehydrogenase.

SOURCE: Acta Medica Polonica 19(3): 305-317, 1978

AUTHOR(S): Zyss, R., J. Krol, and E. Kus

EXPERIMENT TITLE: Morphometric and Cytochemical Investigations of Guinea Pig Myocardium Following Long-Standing Immobilization

SUBJECTS: 210 Guinea pigs (195 gm)

AREA OF STUDY: Circulatory

OBJECTIVES: In title

PROTOCOL: Two groups: 1) 80 control guinea pigs; 2) 130 experimental. The experimental animals were immobilized for 6 mo by placing them in metal cages. The control animals were kept in groups of 5 in large pens. During the experiment all animals were kept in a room at 18-21°C, relative humidity $30 \pm 10\%$ and natural lighting. Measurements: heart weight; number of capillaries in the myocardium; diffusion distance - distance to be covered by oxygen and products of metabolism from the capillary wall to the myocardial fibre, i.e., half the distance between two capillaries on cross-section of the myocardium; thickness of heart walls and thickness of myocardial fibres; cross-section area of cell nuclei; morphometric evaluation of mitochondria - number of, area of cross-section, number of cristae in one cross-section of mitochondrion, calculation of index of cristae density (quotient of the number of cristae on one cross-section of a mitochondrion and the cross-section area of a mitochondrion); cytochemical investigations - activity of succinic dehydrogenase; body weight. Diet: food and water ad libitum.

IMMOBILIZATION METHOD: Cage (metal)

RESULTS: Growth retardation was observed in immobilized animals after six months. Quantitative differences were found between the group of immobilized animals and the controls. Morphometric investigations: lower weight of heart, smaller thickness of ventricular walls and muscle fibres, smaller size of cell nuclei, reduced number of capillaries, greater diffusion difference, lower number of mitochondria, lower value of index of mitochondrial cristae density. Cytochemical investigations: reduced activity of succinic dehydrogenase.

SOURCE: Acta Medica Polonica 19(3): 289-317, 1978

Appendix

REVIEWS

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